9


Count Rumford.

THE

# PHILOSOPHICAL MAGAZINE:

COMPREHENDING

THE VARIOUS BRANCHES OF SCIENCE,

THE LIBERAL AND FINE ARTS,

AGRICULTURE, MANUFACTURES,

AND

COMMERCE.

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*BY ALEXANDER TILLOCH,*

MEMBER OF THE LONDON PHILOSOPHICAL SOCIETY, ETC. ETC.

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"Nec aranearum ſane textus ideo melior, quia ex ſe fila gignunt. Nec noſter vilior quia ex alienis libamus ut apes." JUST. LIPS. *Monit. Polit.* lib. i. cap. 1.

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THE

# PHILOSOPHICAL MAGAZINE.

## I. *History of Astronomy for the Year* 1800. *By* JEROME DE LALANDE *.

THE century now closed has been very remarkable in regard to astronomy: telescopes, indeed, and the laws of Kepler and of attraction, will place the 17th century at the head of all the rest. Nothing had been before done, and the first century, when astronomers began to labour, ought to be that of discoveries. But the 18th century has furnished us with at least twelve epochs so important that it will bear to be compared with the preceding. A new capital planet and eight satellites discovered, the periodical return of comets known and demonstrated, and 68 new comets observed and determined; the aberration and nutation of the stars; the transit of Venus, and the true distance of the sun and of all the planets; the figure of the earth and its irregularities; calculations in regard to the inequalities produced by attraction, and, above all, in regard to Jupiter and Saturn, which have furnished correct tables of all the planets and their satellites; tables of the moon, the most important of all, carried to the precision of a quarter of a minute; and, in the last place, 50,000 stars accurately observed: all these far surpass the hopes which could have been conceived a century ago of the progress of astronomy since that period. To these we must add the improvement of astronomical instruments: sectors, meridian telescopes, whole circles, reflecting circles,

* From *Magazin Encyclopedique*, No. 17, an. 9.

telescopes by Short and Herschel, compensation balances, marine time-keepers, all assumed in the last century a new face.

The conclusion of the last century was remarkable in many respects. Some days before the end of the year 1799, C. Mechain discovered a comet in Ophiuchus; it was observed also by Messier. Mechain and Burckhardt took the earliest opportunity of calculating the elements of it.

What was so tedious and difficult fifty years ago, is at present the work of a few hours. This comet was seen only for a few days, and appeared to the naked eye as a star of the fifth or sixth magnitude. It is the 91st, the orbits of which have been calculated. Its orbit has been calculated also in Germany by M. Olbers and M. De Wahl.

The prize proposed by the Institute for determining the orbit of the comet of 1770, has produced an excellent memoir by Burckhardt, in which the question has been resolved; but, to represent the observations, he has been obliged, like Mr. Lexel, to recur to an orbit of five years. However extraordinary that result may appear, the attraction of Jupiter seems capable of explaining that derangement; but this article would require long discussions.

The grand labour respecting the stars, which we began on the 5th of August 1789, has been continued with courage, and successfully terminated by Le Français-Lalande. He has determined the places of 50,000 stars, from the pole to two or three degrees below the tropic of Capricorn; and he has already begun, with Burckhardt, to review the zodiacal constellations, in the hopes of finding some new planets. Madame Le Français, who has already reduced 10,000 stars, has begun the reduction of the whole number with exemplary ardour. These 50,000 stars, terminated with the 18th century, will, in my opinion, form a remarkable epoch in the increase of our astronomical knowledge during that period.

M. Bode, of Berlin, has published the fourth number of his large and beautiful Celestial Atlas: he announces that the fifth and last will appear in the course of four months, with a preface and index, and a catalogue of 17,000 stars, a great part of which were furnished by me. This atlas con-

sists

ſiſts of twenty large charts. They may be had at the *College de France*, at Paris.

The concluſion of the century has been diſtinguiſhed alſo in a very remarkable manner by the theory of the moon. On the 13th of June Laplace announced a new reſult of the theory, which is a nutation of the lunar orbit, reſulting from the oblate figure of the earth. According to this inequality, we may ſuppoſe that the lunar orbit, inſtead of moving with a conſtant inclination to the ecliptic, moves in a plane paſſing through the equinoxes between the equator and the ecliptic, inclined to the latter at an angle of ſix or ſeven ſeconds. He has found alſo an inequality of the moon, depending on the longitude of the node, which is ſix ſeconds. Diſputes were long maintained reſpecting this inequality, which the Engliſh totally neglected, and which did not ſeem to be indicated by theory.

The motion of the moon during the courſe of 1002 years was attended with a difficulty which has been now removed. The obſervations of the Arabs in the tenth century were of great importance in this reſpect. We were acquainted only with three, when I diſcovered among the manuſcripts of my old maſter, Joſeph Deliſle, an Arabic copy of a part of the work of Ibn Iunis, which contained a great many; but the original was at Leyden; and we long ſolicited the Batavian government to entruſt us with it. At length, on the 26th of May 1799, the ambaſſador brought to the Inſtitute this valuable manuſcript, written in a ſmall character, and forming 400 pages in quarto. Cauſſin is employed in giving a complete tranſlation of it; and we hope, that not only the tranſlation, but alſo the Arabic original, as far as it relates to the obſervations, will be printed at Paris. Cauſſin has already tranſlated that which I procured him. He was aſſiſted by Bouvard in regard to the aſtronomical part and the calculations. The reſults of the obſervations of the moon have been already printed.

The Inſtitute had propoſed as the ſubject of a prize, the compariſon of a great number of obſervations of the moon, with the tables to fix the epochs of the longitude of the moon, of the apogeum, and of the node. The two papers of Burg and Bouvard, which ſhared the prize of the Inſtitute, contain new determinations of the moon's motion, founded on ſo great a number of obſervations, that there is reaſon to think that the tables thence reſulting will never err more than 15 or 20 ſeconds; that is to ſay, one-half or one-third leſs than thoſe which Maſon publiſhed in England. Dr. Maſkelyne made him undertake them by determining the co-efficients of 24 equations of the tables of Mayer by a compariſon with thoſe of Bradley. But the new reſearches are founded on a much greater number of obſervations.

The equations, which De Laplace found by theory, have added to them a greater degree of perfection, and nothing remains but the latitude, for which a new prize ought to be propoſed.

Burg has calculated 3233 of Maſkelyne's obſervations, in order to determine the epoch of the moon. He has again determined alſo the 24 equations of the moon as Maſon has done, but with more correctneſs. Madame Lavit has had the courage to calculate more than 500 places of the moon for the reſearches of Bouvard on the ſame ſubject.

Burckhardt, one of our ableſt and moſt zealous aſtronomers, has calculated tables of the moon, according to the new reſults of Burg, for the uſe of the aſtronomers who have ſet out on a diſtant expedition. They will perhaps find themſelves in ſituations when it will be of importance for them to have the longitudes calculated more exactly than they are either in the Engliſh Nautical Almanack or the French *Connoiſſance des Temps*, which, beſides, may be exhauſted before their return.

The French Board of Longitude has propoſed a prize of 6000 francs (250*l.*) for more perfect tables of the moon, which we ſhall ſoon obtain. This part, therefore, of ſo much importance to aſtronomy and navigation, which has occupied aſtronomers for more than 100 years, is at length terminated in the completeſt and moſt ſatisfactory manner.

De Parceval, an able geometer, has terminated a grand analytical theory of the moon, in which he has given exact formulæ

formulæ for a greater number of equations than are in the tables above mentioned. He proposes publishing a history of the integral calculus.

De Laplace is employed also on the theory of the moon; and we have reason to expect from him new and valuable things. He has given a memoir on the satellites of Saturn and those of Herschel's planet. He has shown that the last satellite of Saturn has a constant inclination, and he determines the motion of its nodes. New considerations in regard to those of Herschel, induce him to think that this planet may maintain in the same plane its first five satellites; but that the case, in all probability, is not the same in regard to the sixth.

Vidal continues to send us rare observations on Mercury, which he has made at Mirepoix. He is our valuable Hermophilus, who sees Mercury every day, and who sees him even at the distance of some minutes from the sun. This astonishing observer has already sent me more than 500 observations of Mercury. He has done more in this respect than all the other astronomers in the world. At Mirepoix, perhaps, it is not known that such a man exists in that small town, but we shall proclaim it to the universe and to posterity.

The minister appointed him director of the national observatory at Thoulouse on the 21st of April last, and a better choice could not have been made.

Michel Le Français-Lalande, my nephew, finding that Mars was the only planet the tables of which were still liable to errors of one or two minutes, has re-calculated all the observations of that planet. Burckhardt has re-calculated the perturbations which I formerly gave in the memoirs of the Academy of Sciences, and which Schubert and Oriani afterwards calculated; and Le Français has presented to the Institute new tables of Mars in tenths of a second, and which give us reason to apprehend no more than a few seconds of error. They are now printing in the *Connoissance des Temps* for the year 12; and the opposition of the 8th of November last has confirmed the correctness of these tables. An exact observation of the 13th, gave an error of only 15 seconds in longitude

longitude and 6 in latitude; and the observation made by Bouvard with the new instruments of the observatory, gave the same number of seconds; which confirms, in a satisfactory manner, the goodness of our instruments and the exactness of our observers.

Triesnecker has undertaken a similar labour at Vienna, and Oriani at Milan. The differences are insensible, but none of the three knew any thing of what was doing by his fellow-labourers.

Wurm has also calculated the perturbations of Mars by the method of Klugel, inserted in the memoirs of the Society of Göttingen. Oriani, Burckhardt, Schubert, and Wurm, do not always agree, but the differences are trifling.

Bouvard is employed in calculating the perturbations of all the planets, as they affect each other, by the formulæ of De Laplace. This will be a very complete work, the result of which will appear in the second volume of the *Mecanique Celeste.*

The transit of Mercury over the sun has afforded me an opportunity of verifying the place of the aphelion by the method which I gave in the memoirs of the Academy for 1786, and which is the most conclusive. By my result it appears that there is no reason for making any change in the tables of Mercury, which I published in the *Connoissance des Temps.* The same agreement in regard to Venus may be seen in the *Connoissance des Temps* for the year 11, p. 456.

For Jupiter we have found the correction to be made in the tables + 34″ in the opposition and + 30″ in the quadrature.

For Saturn the correction in the opposition is — 10″, nearly as the preceding year.

For Herschel's planet I have found — 9″; and Von Zach, by employing five observations, had the same result.

We have reason therefore to be satisfied with the correctness of our tables for all the planets.

In regard to the tables of the sun, I have still found 8 or 10″ too much in our longitudes: whether this arises from a retardation in the motion of the earth for 15 or 20 years past, or from some error respecting the mean motion in the con-

struction

ſtruction of the tables of Delambre and Von Zach. However this may be, I deduct 10″ from the ſun's place in calculations where great preciſion is required.

Delambre does not admit this correction: he ſays, that in the 300 obſervations of Greenwich, which he calculated in order to conſtruct his tables, he compared the ſun with the ſtars which paſſed in the day-time, one before and the other after the ſun; and he adds, that unleſs this precaution is taken, we cannot aſſert that 10″ are to be deducted from his tables.

An account of the grand labour by Delambre reſpecting a degree of the meridian between Dunkirk and Rodez, has been printed. The ſouthern part, executed by Mechain, will next appear.

Vidal continues to ſend us obſervations of the ſtars below the tropic. Bernier, who laboured with me for nine months before his embarkation, reduced them up to the year 1800; and they will ſoon be printed.

Delambre has undertaken to obſerve with a whole circle the declinations of the ſtars of the 1ſt, 2d, and 3d magnitude; which will add a new degree of perfection to the catalogue of the principal ſtars publiſhed annually in the *Connoiſſance des Temps*.

The deſcription of the aſtrolabe planiſphere, found by Gail in Syneſius, has induced Delambre to give a long memoir on the hiſtory of aſtrolabes, their conſtruction, their properties, and the method of finding new reſults even in the moſt hackneyed part of aſtronomy.

Burckhardt has found a formula which repreſents the declinations of the magnetic needle obſerved at Paris ſince the year 1580. It appears from this formula that the period of the declination of the magnetic needle is at Paris 860 years; that the greateſt declination weſt is 30° 4, and will take place in the year 1878: the greateſt eaſtern declination is only 23°.

The printing of the *Hiſtoire celeſte Françaiſe*, which is a collection of all our obſervations, is ſtill continued. My *Bibliographie Aſtronomique* is alſo continued, but the printing-office of the republic is not ſufficient for all the undertakings which have already been begun in it. Chaptal, the

 miniſter

minister of the interior, has given special orders for finishing this volume.

The printing of tables of sines to thousandth parts of the circle has been finished. The late Borda caused them to be calculated under his own inspection. The printing was pretty far advanced, but several things still remained to be done. Delambre put the last hand to them, and verified the calculation in several parts: he corrected the proofs and wrote the explanation.

The decimal tables have been calculated to a much greater extent at the *Bureau du Cadastre* by the care of Prony; but the difficulty of printing them will perhaps greatly retard the advantage we expect from them. If we can get all the astronomical tables reduced to decimal degrees, that is to say, calculated for the hundredth and thousandth parts of a quadrant, astronomical calculations will be much simplified; but a long time may elapse before astronomers will agree in regard to this reformation, though useful.

I have published an edition of the *Mondes de Fontenelle*, with notes and additions. This work, so celebrated, which is still generally read, stood in need of notes for correcting its errors. As Bode had given a German edition of it, and Codrika one in Greek, I thought it my duty to give a new one in French.

I have begun a small portable stereotype edition, in eighteens, of the tables of logarithms, published by Lecaille and myself in 1760, and since reprinted four or five times with a great many faults. This will be the most convenient small-sized edition, and the most correct.

Firmin Didot will insure the beauty of the impression: I have added explanations for the use of those astronomers, philosophers, geographers, surveyors, who may have occasion to employ logarithms; but I have suppressed all useless formulæ.

For a century past astronomers have been continually disputing on the obliquity of the ecliptic and the quantity of its diminution. The circles with which observations may be multiplied at pleasure, presented new means for deciding this question. I caused one of 19 inches radius, the greatest

hitherto

hitherto employed, to be constructed: Français-Lalande and Burckhardt have used it with great success during the two last summer solstices.

Mechain and Delambre have communicated to us their observations, and I now find myself in possession of more than 700: the mean result is, that 5″ 8 must be added to my tables. The mean for the first of January 1800, is 23° 27 58″.

The diminution would be 41″ for a century; and taking as the term of comparison the determinations of Bradley, Mayer, and Lacaille, in 1750, I have found 36″ for a great many other comparisons, particularly the observations of Richer at Cayenne in 1672, the oldest made with any degree of correctness. We have therefore reduced to very little the uncertainty of this element, so necessary in regard to the stars. Duc la Chapelle, with a sextant of six feet, which had been employed by Lacaille, has found 19″ less than that celebrated astronomer did in 1750, being a diminution of 38″ per century.

In the Ephemerides of Vienna for 1800 and 1801, Triesnecker has collected all the calculations of eclipses observed since 1747, in order to deduce from them the longitudes of the cities of Europe and America, and also the errors in the tables. Never were so many eclipses calculated; and that able astronomer has thus rendered a new and very important service to government.

Goudin, who has bestowed great labour on the analytical calculation of eclipses, and who has published several memoirs on that subject, has by his analysis completely determined the circumstances of the eclipse of 1847, the most considerable of the present new century. Duvaucel, to whom we are indebted for the delineation of eclipses for thirty years past, has delineated also this eclipse for every country on the globe: by his diagram it appears that it will be annular in England, France, Turkey, and even Cochinchina.

Duvaucel has delineated also the eclipse of the 11th of February 1804, which will be curious, because it will be total and annular in different countries according to the altitude of the sun: annular at sun-rising in America, and at the setting in

Asia, from nine in the morning till one o'clock; it will be total, with a short duration in the shadow, to the southern part of Europe: there is reason to think that some voyages will be undertaken on this occasion, since it will be an uncommon opportunity for determining the differences of the diameters of the sun and moon, the irradiation and inflection. These diagrams of eclipses have hitherto appeared in the Ephemerides of Paris and in those of Bologna; but those in the Ephemerides of Paris terminated with 1800, and in those of Bologna, which go as far as 1810, there is only one diagram for 1804; four are wanting, *viz.* of 1802, 1803, 1806, and 1807. Duvaucel purposes to construct them, and particularly the last two.

Cagnoli, an astronomer of Verona and professor at Modena, has been left in peace during the invasion of the Cisalpine republic by the Austrians; and, by means of the pension assigned to him by Bonaparte, he has published the eighth volume of the Memoirs of the Italian Society, in which he has given some memoirs on astronomy.

Bode, in the Ephemerides of Berlin for 1802, has published a great many memoirs, observations, and calculations, by himself and by Wurm, Mechain, Olbers, Casella, Koch, Koehler, Triesnecker, Burg, Schrœter, Klugel, Seyffert, Hennert, Schubert, Dersilinger, Hahn, Kautsch, Fritsch, and Schaubach.

In the *Connoissance des Temps* for the year 11, which has just appeared, there are a multitude of observations and calculations by Laplace, Delambre, Vidal, Messier, Lachapelle, Sorlin, Mougin, Quenot, Burckhardt, Thulis, Poitevin, Bernier, and myself, and a catalogue of 2300 new stars by Le Français-Lalande and Vidal.

This volume consists of more than 500 pages, agreeably to the decision of the Board of Longitude, which I requested several years ago, and yet I have still in my hands materials which I was not able to employ.

I shall embrace this opportunity to inform those who have the *Connoissance des Temps* for the year 9, without the additions, that they have been published separately under the title of *Melanges d'Astronomie*, and that with the first part they form

form the 500 pages as above announced. It was apprehended that the use of the old calendar and the old measures found in this work would thwart the projects of government, and this sacrifice was made for the sake of peace. But the amateurs of this collection of the *Connoissance des Temps* will be deceived if they have the volume of the year 9 without the *Melanges*.

In these *Melanges*, page 282, I announced the publication of Malespina's Voyage round the World; but it has not taken place, and that officer is still in prison. I am, however, of opinion, that in the maps about to be published in Spain, advantage will be taken of his observations.

The Memoirs of the French National Institute, vol. ii. for the year 5, were published on the 12th of November 1799. They contain calculations of two comets and several eclipses already observed; the theory of the secular equation of the moon by Laplace, the discovery of which we announced, and which may be found also in the *Mecanique Celeste*, that grand and important work, of which we have already spoken, and of which three long extracts were published by Briot in the *Magazine Encyclopedique*. Burckhardt has given a German translation of it, that his former country may enjoy the valuable discoveries of Laplace.

In the Philosophical Transactions for 1799, there is a new method for finding the latitude by two altitudes of the sun, and the interval of time elapsed, by Mr. Lax, professor of astronomy at Cambridge. Also, a fourth catalogue of stars, compared with each other in order to estimate their degree of light, by Dr. Herschel.

In the Transactions for 1800, there is an interesting memoir, by Dr. Herschel, on the power of telescopes to penetrate into space; that is to say, to render sensible very distant and very faint objects, which, by their want of light, would be imperceptible without the aid of instruments; useful remarks on the difference between that force of light and that of amplification or enlargement; on the different cases to which either is applicable, and the means of procuring the necessary degree of light. He gives calculations also of the loss of light occasioned by mirrors or glasses. It appears to him that the greatest amplification cannot exceed that produced by by a telescope of from 20 to 25 feet, and such a celebrated optician is worthy of credit. The 16th number of the *Bibliotheque Britannique*, published at Geneva, contains a large extract from this paper. In the Transactions of 1800, Dr. Herschel gives a long paper on the influence of the different solar rays and those of terrestrial bodies to communicate light and heat: he has found that the yellow rays illuminate most, and that the red communicate the greatest degree of heat. Astronomers will make use of this information when they observe the sun. This paper contains a series of curious experiments on light.

Mr. Playfair, in the fifth volume of the Edinburgh Transactions, has given formulæ for the figure of the earth.

A valuable work for geometry, which treats of the calculus of derivations published by Arbogast, one of our greatest geometricians, deserves a place in our history of astronomy. This work, in page 355, contains an application of the calculus of derivations to series which proceed according to the sines or cosines of the multiples of the same angle: his methods give more facility and perfection to the manner of treating them.

I have received the Ephemerides of Milan for the year 1800, which contain the perturbations of Mars, calculated by Oriani, and his tables of Mars, which will form part of the Ephemerides for 1801. I have received also the Ephemerides from Rome by Oddi, who occupies the observatory Gaetani, and the Nautical Almanack for 1804, which Sir Joseph Banks transmitted to us with his usual zeal.

Gudin has published a poem of 600 lines, containing a history of astronomy and an account of the present state of that science. The author has added very copious and instructive notes. This poem is already employed as an agreeable fund of instruction for youth under the care of a well known preceptor. But, after so many interesting works, the historian is obliged to announce one more voluminous, called *Principes naturels, ou Notions generales et particulieres de l'Immensité de l'Espace, de l'Univers, des Corps celestes*, &c. by Lejoyand, five volumes quarto, in which the author pretends, to the disgrace of our country and of the present age, to destroy the systems of Newton and Descartes.

During the first years of the revolution the national observatory was neglected: as soon as I was appointed director of it I solicited for new instruments; and Mechain, when he returned from his voyages, employed himself in causing the necessary reparations to be made. By the month of July the new instruments were erected, but it was not till the 22d of August that Mechain was able to begin his observations of the moon. Bouvard supplies his place with that zeal by which he is so much distinguished; and we shall have at Paris a series of observations of the moon that may equal those made at the observatory of Greenwich.

The large mural quadrant of $7\frac{1}{2}$ feet, which Bonaparte procured for us, as I mentioned in my History of Astronomy for the year 7, has been erected.

Lenoir has added to the centre an ingenious machine, which eases the central axis from the weight of the telescope, and varies according as the elevation of the telescope is changed. A mural of five feet, made in England by Sisson in 1743, and which I had at Berlin in 1751, has been erected on the northern side. An excellent transit instrument by Lenoir has been placed in the meridian, and sights have been fixed up north and south at great distances, that the telescope may be always exactly in the meridian: there is reason to hope that we shall have a column in the plain, with a light to be kindled in the evening, which will serve during the night.

[To be continued.]

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II. *A brief Account of the Manufacture of Gilt Buttons, comprising some Improvements important to Manufacturers. Communicated by Messrs.* Collard *and* Fraser, *of Birmingham.*

As the means employed in the manufacture of plain gilt buttons are not universally known, the following summary, while it points out to the manufacturer many considerable advantages, in the use and recovery of his mercury, will also, it is hoped, be found interesting to many readers of the Philosophical Magazine.

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The copper, properly alloyed, is firſt taken to a rolling mill, and reduced between iron rollers to a proper thickneſs for the button. The ſheets of copper are then brought to the button manufactory, and cut into circular pieces of the ſize of the intended button by means of a fly-preſs. In this ſtate they are called *blanks*, and reſemble halfpence and farthings worn ſmooth by long circulation.

The ſhanks, which are made with wonderful facility and expedition by means of a very curious machine, are then ſecured to the bottom of each button by a ſmall iron crank, and a ſmall quantity of ſolder and réſin applied to each. Thus they are placed on a ſheet of iron, containing about a groſs, and introduced into a very hot ſtove, where they remain till the workman is ſatisfied that the ſolder has melted, and that the ſhanks are united to the button; after which the edges are ſmoothed in a lathe.

The next proceſs is what they call *dipping*; that is, a quantity, conſiſting of a few dozens, is put into an earthen veſſel full of ſmall holes like a cullender, and thus dipped into diluted nitric acid to clean them from dirt and ruſt. They then, according to the beſt practice, go into the hands of the burniſher, who, in a lathe, burniſhes the tops, bottoms, and edges, with a hard black ſtone, got from Derbyſhire, ſecured in a handle like the diamond of a glazier: this he applies to the button fixed in the end of a piece of wood, turned with great velocity by means of a treddle with which he works the lathe. This is called *rough burniſhing*, and is a modern improvement: it is of great advantage, for it cloſes the pores of the metal opened by the acid, ſo that the gold afterwards to be applied attaches to a ſmooth ſurface, which otherwiſe might enter into imperceptible cavities, and be cloſed up in the body of the button by the final burniſhing. When the buttons come from the burniſher they are fit for gilding. This is a very curious operation, and truly chemical.

The firſt proceſs towards gilding is what they call *quicking*, which is effected as follows:—Any given quantity of buttons, perhaps a groſs, is put into an earthen veſſel with a quantity of mercury which has been previouſly ſaturated with nitric acid: and thus the buttons and mercury are ſtirred together with

with a brush till the mercury, carried by the affinity of the acid to the copper, adheres to the whole surface of the button. The buttons are then taken out and put into what is called a *basket*, though in fact an earthen vessel full of small holes, the handle of which the operator holds in his hand, and jerks it with considerable force down towards a wooden trough (a receptacle for the quicksilver) till, by repeated jerks, all the loose particles of mercury are disengaged, leaving a complete continuity over the surface, and giving them the appearance of silver buttons.

Now the gold, a grain of which will spread over many superficial feet of copper, is thus prepared: Any given quantity of mercury is poured into an iron ladle, the inside of which having been previously *guarded*,—that is, rubbed over with dry whiting to prevent the gold from adhering to the iron,—into this mercury is thrown the portion of pure gold intended to cover a given quantity of buttons. The gold and mercury are heated together in the iron ladle till the workman (whose practice soon enables him to judge) perceives that there is a perfect union between them; when he empties his ladle into a vessel containing cold water.

The amalgam being cold, is put into a piece of shammoy leather, and squeezed till no more mercury will pass through. What passes the shammoy contains not the smallest portion of gold; what remains will be about the consistency of butter, so completely united that every particle of mercury shall contain an equal portion of gold. The amalgam should be then put into an earthen vessel, and a small quantity of nitric acid added thereto, allowing sufficient time for the acid to unite with the mercury. But the buttons and amalgam are commonly introduced first, and a quantity of diluted nitric acid added thereto, so that, for want of a complete union between the mercury and acid first, if there be not a superabundancy of acid, there may not be sufficient to carry all the amalgam to the surface of the buttons.

When the acid has had sufficient time to *embrace* (as workmen call it) the mercury, the buttons should be introduced, and be stirred till the amalgam, carried by the affinity of the

 acid

acid to the copper, and the tendency which the gold has to extend itſelf to the mercury with which the buttons have been previouſly quicked, completely attaches to the whole ſurface.

It is the next proceſs in which we principally wiſh to recommend a deviation from the old practice, by which moſt of the mercury will be recovered, and the gilder's health, in a great meaſure, preſerved from the dreadful effects of volatiliſed mercury.

The old practice is as follows: The buttons being completely covered with mercury and gold, the operator proceeds to that buſineſs which is called *drying-off*, which is performed thus: The buttons, to the quantity of a few dozens, are put into an iron pan ſomewhat like a large frying-pan, placed over a fire, and gently ſhook, while the operator watches carefully till he obſerves the mercury begin to flow;—upon the firſt ſymptom of which, he takes the pan from the fire, and throws the buttons into a large cap, called a *gilding cap*, like a man's hat with a very ſmall brim, but much larger in the crown, made of coarſe wool and goats hair. In this cap, with a circular bruſh, the buttons are ſtirred, to ſpread the gold and mercury while in a degree of temperature nearly ſufficient to volatiliſe the mercury. The buttons are again thrown into the pan, placed over the fire, and ſhaken, while the mercury gently volatiliſes. The buttons are again thrown into the cap, and ſtirred with the bruſh. This proceſs is continually repeated, till all the mercury is volatiliſed, leaving the gold on the buttons, which appear again of a yellow colour.

Thus a principal part of the mercury aſcends the chimneys, is depoſited on the tops of the houſes and about the adjacent neighbourhood, and great quantities are inhaled and abſorbed by the operator, keeping him nearly in a ſtate of ſalivation till diſeaſe obliges him to deſiſt.

Conſiderable quantities of mercury thus volatiliſed are found united and collected in ſmall pools in the ſpouts and gutters on the tops of the buildings. Thus many tons of mercury have been diſſipated about the town and neighbourhood of Birmingham, to the great injury of the inhabitants. The poor fweep who has afcended the chimneys has been falivated, and the manufacturer has fuftained confiderable lofs.

To preferve a principal part of the mercury thus diffipated, and to prevent, in a great meafure, the terrible effects of it on the conftitution of the operator, is the object of thefe remarks, as far as it regards manufacturers.

By means of an apparatus fimilar to the plan delineated in Plate I. fig. 3. which has been partially and fuccefsfully adopted by Mr. Mark Sanders, an eminent button-maker of Birmingham, the principal part of the mercury may be recovered, and the health of the operator greatly preferved.

A hearth of the ufual height is to be erected, in the middle of which a capacity for the fire is to be made; but inftead of permitting the fmoke to afcend into the top A, made of fheet or caft iron, through which the mercury is volatilifed, a flue for that purpofe fhould be conducted backwards to the chimney B. An iron plate, thick enough to contain heat fufficient to volatilife the mercury, is to cover the fire-place at the top of the hearth C. There muft be an afh-hole, D, under the fire-place. The fquare fpace E, feen in the fire-place, is the flue, which ferves to carry the fmoke back under the hearth into the chimney B. The door of the fire-place and afh-pit may either be in front, as reprefented in the plate, or at the end of the hearth at F, which will perhaps lefs incommode the work-people. It would be of great advantage if the fpace between A and the iron plate C was covered up with a glafs window coming down fo low as only to leave fufficient room for moving the pan backwards and forwards with facility. If the fides were alfo glafs inftead of brick-work it would be ftill better, as the work-people would be able to have a full view of their work without being expofed to the fumes of the mercury, which, when volatilifed by heat communicated to the pan by the heated iron plate over the fire-place, would afcend into the top A, appropriated for its reception, and defcend into the tub G, covered at top and filled pretty high with water. By this means the hearth would, in fact, become a diftilling apparatus for condenfing and recovering the volatilifed mercury. In the tub G the principal part would be recovered; for, of what may ftill pafs on, a part would be condenfed in afcending the tube H, and fall back, while the remainder would be effectually caught in the tub or cafk I, open at the top and partly filled with water. The latter tub fhould be on the outfide of the building, and the defcending branch of the tube H fhould go down into it at leaft 18 inches, but not into the water. The chimney or the afh-pit fhould be furnifhed with a damper to regulate the heat of the fire.

The water may be occafionally drawn out of the tubs by a fiphon, and the mercury clogged with heterogeneous matter may be triturated in a piece of flannel till it paffes through, or placed in a pan of fheet iron, like a dripping-pan, in a fufficient degree of heat, giving it a tolerable inclination, fo that the mercury, as it gets warm, may run down and unite in the lower part of the pan. But the mercury will be moft effectually recovered by expofing the refiduum left in the flannel bag to diftillation in a retort made of iron or of earthenware.

When the mercury is volatilifed from the buttons, or, as the workmen denominate it, when the buttons are dryed off, they are finally burnifhed, and are then finifhed and fit for carding.

The reader unacquainted with this branch of manufacture will be furprifed to learn how far a fmall quantity of gold, incorporated with mercury, will fpread over a fmooth furface of copper. Five grains, worth one fhilling and threepence, on the top of a grofs, that is, 144 buttons, each of one inch diameter, are fufficient to excufe the manufacturer from the penalty inflicted by an act of parliament; yet many, upon an affay are found to be deficient of this fmall quantity, and the maker fined and the buttons forfeited accordingly. Many hundred groffes have been tolerably gilt with half that quantity; fo extremely far can gold be fpread, when incorporated with mercury, over the furface of a fmooth piece of copper*.

* The gentlemen to whom we are indebted for this communication have fent us fpecimens of a new kind of verdigris, of their manufacture, fit for all the purpofes of dyeing; and a beautiful new colour for painters, which they call *celeftial green*. They both promife to be ufeful articles.—EDIT.

III. *A*

## III. *A Treatise on the Cultivation of the Vine, and the Method of making Wines.* *By* C. CHAPTAL*.

THERE are few natural productions employed by man as aliment, which he has not altered or modified by preparations which remove them from their primitive ſtate. Corn, fleſh, and fruits, are all ſubjected to a commencement of fermentation before they are uſed as nouriſhment; and peculiar qualities are given even to objects of luxury, caprice, or whim, ſuch as tobacco and perfumes.

But it is in the fabrication of liquors in particular that man has diſplayed the greateſt ſagacity: all are the work of his own creation, water and milk excepted. Nature never furniſhes ſpirituous liquors: it ſuffers the grapes to rot on the ſtems, while art converts the juice into an agreeable, tonic, and nouriſhing liquor called *wine*.

It is difficult to aſcertain the preciſe period when mankind began to make wine. This valuable diſcovery ſeems to be loſt in the darkneſs of antiquity, and the origin of wine has its fables, like all other things which have become objects of general utility.

We are told by Athenæus that Oreſtes, the ſon of Deucalion, came to reign at Ethna, where he planted vines. Hiſtorians agree in conſidering Noah as the firſt who made wine in Illyria, Saturn in Crete, Bacchus in India, Oſiris in Egypt, and king Geryon in Spain. A poet, who aſſigns every thing to a divine ſource, is inclined to believe that after the deluge God granted wine to man to conſole him in his miſery, and he expreſſes himſelf thus reſpecting its origin:

> Omnia vaſtatis ergo cum cerneret arvis
> Deſolata Deus, nobis felicia vini
> Dona dedit, triſtes hominum quo munere fovit
> Reliquias; mundi ſolatus vite ruinam. *Vanerii Præd. Ruſt.*

Even the etymology of the word wine has given riſe to different opinions among authors; but from that long ſeries of fables with which the poets, who are always bad hiſtorians, have obſcured the origin of wine, we may collect ſome va-

* From *Cours d'Agriculture de Rozier,* Vol. X.

luable

luable truths, and among these we may venture to clafs the following:

The earlieft authors not only atteft that they were acquainted with the art of making wine, but that they had fome very correct ideas in regard to its different qualities and virtues, and the various ways of preparing it. The heathen deities, we are told, delighted in nectar and ambrofia.

Diofcorides fpeaks of the *Cæcubum dulce*, the *Surrentinum aufterum*, &c.; and Pliny defcribes two kinds of Alban wine, the one mild, and the other fharp and tart. The celebrated Falernian wine, according to Athenæus, was alfo of two kinds. The antients were even acquainted with brifk wines, as appears by the following paffage of Virgil:

——————Ille impiger haufit
Spumantem pateram ——————

When we read what hiftorians have left us refpecting the origin of the wines poffeffed by the antient Romans, it feems doubtful whether their fucceffors have added any thing to their knowledge on that fubject. They procured their beft wines from Campania, called at prefent Terra di Lavori, in the kingdom of Naples. The Falernian and Maffic wine were the produce of vineyards planted on the hills around Mondragon, at the foot of which runs the Garigliano, formerly called the Iris. The wines of Amicla and Fondi were made in the neighbourhood of Gaeta, the grapes of Sueffa grew near the fea, &c. But notwithftanding the great variety of wine produced by the foil of Italy, luxury foon induced the Romans to feek for that of Afia, and their tables were loaded with the valuable wines of Chio, Lefbos, Ephefus, Cos, and Clazomene.

The earlieft hiftorians who have furnifhed us with any pofitive facts refpecting the making of wines, leave us no reafon to doubt that the Greeks had made confiderable progrefs in the art of preparing and preferving them. They diftinguifhed them into two kinds, *protopon* and *deuterion*, according as they were produced from the juice which flowed from the grapes before they were trod upon, or from the juice expreffed by treading them. The Romans afterwards denoted thefe these two kinds of wine by the terms *vinum primarium* and *vinum secundum*.

When we read with attention what Aristotle and Galen have handed down to us on the preparation and virtues of the most celebrated wines of their time, we can hardly help believing that the antients possessed the art of thickening and drying certain kinds of wine in order to preserve them for a long time. Aristotle tells us expressly that the wines of Arcadia became so dry in the leather bags in which they were kept, that it was necessary to scrape them off and dilute them with water before they could be fit for drinking: *Ita exsiccatur in utribus ut derasum bibatur.* Pliny speaks of wines kept for a hundred years which had become as thick as honey, and which could not be drunk till diluted with warm water and strained through a cloth. This was called *saccatio vinorum.* According to Martial, Cæcuban wine ought to be filtered in that manner:

Turbida sollicito transmittere Cæcuba sacco.

Galen speaks of some wines of Asia, which, when put into large bottles suspended near the fire, acquired by evaporation the solidity of salt. This operation was called *fumarium.*

It was certainly wine of this nature that the antients preserved in the upper part of their houses, and in a southern exposure: these places were distinguished by the appellations of *horreum vinarium, apotheca vinaria.*

But all these facts can relate only to mild, thick, and little fermented wines, or to juices not altered and concentrated. They were extracts rather than liquors, and perhaps they were only resinous substances similar to that which we form at present by the inspissation and concentration of the juice of the grape.

The antients were acquainted also with light wines, which were drunk immediately: *quale in Italia quod Gauranum vocant et Albanum, et quæ in Sabinis et in Tuscis nascuntur.* They considered recent wines as hot in the first degree, and the oldest were considered as the hottest.

Each kind of wine had a known and determinate period before which it could not be employed for drinking. Dioscorides fixes this period at the seventh year, as a mean term. According to Galen and Athenæus, Falernian wine was never drunk, in general, until it had attained the age of ten years, and never after the age of twenty. The Alban wines required the age of twenty years, the Surrentine twenty-five, &c. Macrobius relates that Cicero, being at supper with Damisippus, was treated with Falernian wine of forty years, which Cicero praised by observing that it bore its age well: *benè, inquit, ætatem fert.* Pliny speaks of wine served up at the table of Caligula which was more than 160 years old. Horace celebrates wine of a hundred leaves, &c.

## I. *On Wine considered in regard to Climate, Soil, Exposure, Seasons, Culture, &c.*

1st, *Climate.*—All climates are not proper for the cultivation of the vine: if this plant seems to vegetate with vigour in the northern climates, it is certain that the fruit can never there acquire a sufficient degree of maturity; and it is an invariable truth, that beyond the 50th degree of latitude the juice of the grape cannot experience that fermentation which converts it into an agreeable beverage.

The case with the vine in regard to climate is the same as with other vegetable productions. We find towards the north a vigorous vegetation, plants well nourished, and succulent; while the south exhibits productions charged with aroma, resin, and volatile oil; here every thing is converted into *spirit*, there every thing is employed to produce *strength*. These characters, so striking in vegetation, occur in the phænomena of animalisation; where *spirit* and *sensibility* seem to be appendages of the southern climates, while *strength* seems to be the attribute of the inhabitant of the north.

Travellers in England have observed that some of the insipid vegetables of Greenland acquire taste and smell in the gardens near London. Reynier found that the melilot, which has a strong penetrating smell in warm climates, retained none in Holland. Every body knows that the highly subtile poison of certain plants and animals is successively blunted or extinguished in the individuals reared in climates lying further towards the north.

Sugar

Sugar itſelf ſeems not to expand in a complete manner but in warm countries. The ſugar-canes cultivated in our gardens furniſh ſcarcely any ſaccharine principle; and grapes are ſour, harſh, or inſipid, beyond the 50th degree of latitude.

The aroma, or perfume of the grapes, as well as the ſaccharine principle, are the production then of a bright and a conſtant ſun. The ſour or harſh juice produced in grapes during the firſt period of their formation cannot be properly matured in the north, and this primitive character of greenneſs ſtill exiſts when the firſt froſts come to freeze the organs of maturation.

Thus, in the north, the grapes rich in principles of putrefaction contain ſcarcely any element of ſpirituous fermentation, and the expreſſed juice of the fruit, having experienced the phænomena of fermentation, produces a ſour liquor, in which there exiſts only that proportion of alcohol neceſſary for interrupting the movements of putrid fermentation.

The vine, therefore, as well as the other productions of nature, has climates peculiar to itſelf: it is between the 40th and 50th degrees of latitude that this vegetable production can be cultivated with any degree of advantage. It is alſo between theſe points that the moſt celebrated vineyards are found, and the countries richeſt in vines; ſuch as Spain, Portugal, France, Italy, Auſtria, Styria, Carinthia, Hungary, Tranſylvania, and a part of Greece.

But of all countries none perhaps preſents ſo happy a ſituation for the vine as France; none exhibits ſo large an extent of vineyards, nor expoſures more varied; and no country has ſuch an aſtoniſhing variety of temperature. From the banks of the Rhine to the bottom of the Pyrenees the vine is almoſt every where cultivated, and in this vaſt extent the moſt agreeable and moſt ſpirituous wines of Europe are to be found.

But though climate ſtamps a general and indelible character on its productions, there are certain circumſtances which modify and limit its action; and it is only by carefully attending to what each of them produces that we can be able to diſcover the effect of climate alone. It is thus that we often find the different qualities of wine united under the ſame climate, becaufe the foil, expofure, and cultivation, modify and mafk the immediate action of that grand agent.

On the other hand, there are fome vine plants which do not leave us the choice of cultivating them indifcriminately in any latitude at pleafure. Soil, climate, expofure, cultivation, all ought to be appropriated to their inflexible nature; and the leaft violation of this natural character effentially alters the product. Thus, the vines of Greece tranfported to Italy no longer produced the fame wine; and thofe of Falernum, cultivated at the bottom of Vefuvius, have changed their nature. It is confirmed by daily experience that the plants of Burgundy tranfported to the fouth no longer produce wines fo agreeable and delicate.

It is therefore proved that the characters by which certain vines are diftinguifhed cannot be reproduced in different fites; for this purpofe the conftant influence of the fame caufes is neceffary, and, as it is impoffible to unite them all, the confequence muft be changes and modifications.

We may therefore conclude that warm climates, by favouring the formation of the faccharine principle, muft produce wines highly fpirituous, as fugar is neceffary to their formation. But the fermentation muft be conducted in fuch a manner as to decompofe all the fugar of the grapes, otherwife the refult will be wines exceedingly lufcious and fweet, as has been obferved in fome of the fouthern countries, and in all cafes where the faccharine juice of the grapes is too much concentrated to experience a complete decompofition.

The cold climates can give birth only to weak and exceedingly aqueous wines, which have fometimes an agreeable flavour; the grapes, in which fcarcely any faccharine principle exifts, cannot contribute towards the production of alcohol, which forms the whole ftrength of wines. But, on the other hand, as the heat arifing from the fermentation of thefe grapes is very moderate, the aromatic principle is preferved in its full force, and contributes to render thefe liquors exceedingly agreeable, though weak.

2. *Soil.*—The vine grows every where, and, if we could judge of the quality of it by the vigour of its vegetation, it is

in fat moiſt ſoil, well dunged, that it ought to be cultivated. But we are taught by experience that the goodneſs of wine is never proportioned to the force of the vine. We may therefore ſay that nature, deſirous to aſſign to each quality of ſoil a peculiar production, has reſerved dry light ſoil for the vine, and has entruſted the cultivation of corn to fat and well nurtured lands:

Hic ſegetes, illic veniunt felicius uvæ.

It is in conſequence of this admirable diſtribution that agriculture covers with its varied productions the ſurface of our globe; and nothing is neceſſary but to avoid deranging the natural order, and to apply to each place the proper cultivation to obtain almoſt every where abundant and varied crops:

Nec vero terræ ferre omnes omnia poſſunt:
Naſcuntur ſteriles ſaxoſis montibus orni;
Littora myrthetis lætiſſima: denique apertos
Bacchus amat colles.

Strong argillaceous earth is not at all proper for the cultivation of the vine; for not only are the roots prevented from extending themſelves in ramifications, as is the caſe in fat and compact ſoil; but the facility with which theſe ſtrata are penetrated by water, and the obſtinacy with which they retain it, maintain a permanent ſtate of humidity, which rots the root, and gives to all the individuals of the vine ſymptoms of weakneſs, which ſoon end in their deſtruction.

There are ſome kinds of ſtrong earth which do not poſſeſs thoſe hurtful qualities that belong to the argillaceous ſoil above mentioned. Here the vine grows and vegetates in freedom; but this ſtrength of vegetation ſtill eſſentially hurts the good quality of the grapes, which can with difficulty acquire maturity, and gives the wine neither ſpirit nor flavour. Theſe kinds of ſoil, however, are ſometimes ſet apart for the vine, becauſe its abundance makes up for its quality, and becauſe it is often more advantageous for the farmer to cultivate the vine than to ſow corn. Beſides, theſe weak but abundant wines furniſh a beverage ſuited to labourers of every claſs, and are attended with advantage in regard to diſtillation, as the vines require little culture.

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It is well known to all farmers that moiſt ſoil is not proper for the cultivation of the vine. If the ſoil, continually moiſtened, is of a fat nature, the plant languiſhes in it, rots, and dies: on the other hand, if the ſoil be open, light, and calcareous, the vegetation may be ſtrong and vigorous, but the wine ariſing from it cannot fail to be aqueous, weak, and deſtitute of flavour.

Calcareous ſoil in general is proper for the vine: being arid, dry, and light, it affords a proper ſupport to the plant; the water with which it becomes occaſionally impregnated circulates, and freely penetrates through the whole ſtratum; the numerous ramifications of the roots imbibe it at every pore; and in all theſe points of view calcareous ſoil is very favourable to the vine. In general, wines produced in calcareous ſoil are ſpiritous, and the cultivation is ſo much the eaſier, as the ſoil is light and not ſtrongly connected; beſides, it is to be obſerved that theſe dry ſoils appear excluſively deſtined for the vine: the want of water, mould, and manure, oppoſe the idea of every other cultivation.

But there are ſome kinds of ſoil ſtill more favourable to the vine, thoſe which are at the ſame time light and pebbly: the root eaſily forces itſelf through a ſoil, which, by a mixture of light earth and pebbles, is rendered exceedingly permeable. The ſtratum of *galets* which covers the ſurface of the earth defends it from the drying ardour of the ſun; and while the ſtem and the grapes receive the benign influence of that luminary, the root, properly moiſtened, furniſhes the juice neceſſary for the labour of vegetation. Soil of this kind is called in different countries, ſtony ſoil, ſandy ſoil, &c.

Volcanic earth alſo produces delicious wines. I have had occaſion to obſerve in different parts of the ſouth of France that the moſt vigorous vines and the moſt capital wines were produced among the remains of volcanoes. Theſe virgin earths, prepared for a long time in the boſom of the earth by ſubterranean fires, exhibit an intimate mixture of all the earthy principles; their ſemi-vitrified texture, decompoſed by the combined action of the air and water, furniſhes all the elements of good vegetation, and the fire with which theſe earths have been impregnated, ſeems to paſs in ſucceſſion into

all

all the plants intrusted to them. The wines of Tokay and the best wines of Italy are the production of volcanic soil; the last bishop of Agde dug up, and planted with vines the old volcano of the mountain, at the bottom of which that antient town is situated, and these plantations form at present one of the richest vineyards in that canton.

There are points on the variegated surface of our globe where the granite no longer presents that hardness and unalterability which in general form the character of that primitive rock: in these places it is pulverulent, and presents to the eye nothing but dry sand of greater or less coarseness: it is among these remains that the vine is cultivated in several parts of France; and, when a favourable exposure concurs to assist the increase, the wine is of a superior quality. The famous Hermitage wine is produced amidst similar ruins. From these principles it may be readily judged, that a soil like that of France must be favourable to the formation of good wine; as it exhibits that lightness of soil which permits the roots to extend themselves, and allows the water to filter through it, and the air to penetrate it: that flinty crust which moderates and checks the ardour of the sun; that valuable mixture of earthy elements, the composition of which seems so advantageous to every kind of vegetation.

Thus, the farmer, more anxious to obtain wine of a good quality than an abundant vintage, will establish his vineyard in light pebbly soil; and he will not make choice of a fat rich soil unless he intends to sacrifice quality to quantity*.

[To be continued.]

IV. *Descrip-*

* Though the principles here established are proved almost by general observation, we must not, however, conclude that there are no exceptions. Creuzé-Latouche observes in a memoir read in the Agricultural Society of La Seine, that the valuable vines of Aï, Epernay, and Hautvillers sur la Marne have the same exposure, and grow in the same soil and land as those in the neighbourhood. The same author observes, that attempts have been made to convert corn lands into vineyards; but it is probable that the experiments have not been attended with success, and that, consequently, there are causes of difference which cannot be discovered by mere inspection.

This author adds, that the primitive earth in the vineyards of the first rank

IV. *Description of an improved Family Oven invented by Mr.* S. Holmes, *of Castle-court in the Strand, London*.*

"The ovens in general use are made with flues, which destroy a great quantity of fire in its passage through them, and much trouble is required to keep them heated. The fire which should be employed in roasting meat, is in a great measure dissipated in the flue of the common ovens, if used at the time of roasting, or the common oven does not acquire sufficient heat to answer the purpose, unless much coal is consumed.

"My invention consists of a cast-iron oven, with a solid piece of iron projecting from its side into the fire, in which this piece constantly remains, and, becoming red hot, communicates sufficient heat for baking to the whole oven, and even assists the fire in roasting.

"My oven keeps continually at a baking-heat, without expence or trouble, as the common fire is sufficient for the purpose. The first oven, which I made for experiment, was fixed in my own house, for use, eighteen months ago, and may be viewed at any time the Society think proper. Others are also in use at Mr. Blackmore's, in Brompton; Mr. Esdale's, the Banker, in Clapham; Mr. Robinson's, at Kensington; Mr. Roe's, at Battersea; and the Rev. Mr. Wise's, at Carlwood; all of which have even exceeded my expectations."

Mr. Holmes's letter to the Society of Arts, &c. of which the above is an extract, is accompanied with several certificates from different gentlemen, all agreeing in stating that these ovens answer every purpose for which they are intended. We have seen them in use, and think them preferable to any oven made of iron we have before seen.

rank in Champagne, are covered with an artificial stratum formed by a mixture of turf and rotten dung, common earth taken from the sides of the hills, and sometimes of black and rotten sand. These kinds of earth are carried to the vineyards all the year through, except in vintage time.

* From the *Transactions of the Society for the Encouragement of Arts, Manufactures, and Commerce*, Vol. XVIII, 1800.

"In

" In order to ascertain fully how the oven answered, a committee, appointed by the Society for the Encouragement of Arts, &c. ordered two ovens, of similar forms and dimensions, to be fixed to the sides of a fire-grate in the model-room of the Society, one of which ovens only differed from the other by the piece of cast iron projecting from its side into the fire: both ovens were heated by the same fire, and fixed in mortar and brick-work in a similar manner.

" Two loaves, of equal size and quality, being prepared from the same dough, one was put into each oven; and after remaining therein three quarters of an hour, they were taken out at the same time, and examined. The loaf from Mr. Holmes's oven was in every respect well baked, but the other was dough-baked and imperfect. An oven upon Mr. Holmes's construction has been since fitted up in the Register's kitchen, which appears to answer every purpose that could be expected from its size, which is 13½ inches wide at the door, or in front, and 15 inches deep.

" A reference to Plate I. fig. 1 and 2, will explain more fully the construction of the oven, and its principle of action.

" Fig. 1. A perspective view of the oven. Fig. 2. A horizontal section of the same. A that side of the oven which is placed next the fire. B the projecting piece of iron which remains stationary in the fire, and communicates heat to the oven. C the door of the oven."

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## V. *Account of the Under-ground inclined Plane executed at Walkden-Moor, in Lancashire, by his Grace the Duke of Bridgewater. By the Rev.* FRANCIS H. EGERTON *.

I BEG leave to present to the Society an account of the under-ground inclined plane which the Duke of Bridgewater has lately made at Walkden-Moor, between Worsley and

* From *Transactions of the Society for the Encouragement of Arts, Manufactures, and Commerce*, Vol. XVIII. The Society voted to his Grace the gold medal, as a testimony of the high opinion entertained by the Society of his Grace's execution of this great work, and his wonderful exertions in inland navigation.

and Bolton, in Lancashire. To this account I have subjoined two plans, with a table of reference to each.

At Worsley the Duke of Bridgewater's navigation begins; it goes west to Leigh, and east to Manchester, where it locks up into the Rochdale canal. In its way to Manchester, it turns out, in a western direction, near Longford Bridge, to meet the Grand Trunk Canal above Preston Brook; and from thence it goes north-west to Runcorn, where it locks down into the Mersey, in the tide-way to Liverpool.

To this navigation above-ground, which, in all its directions, is extended through a length of forty* miles, upon one level, without tunnel or lock, except the locks at the extremities. At Worsley, an under-ground navigation is joined, which goes to the different mines of coal under Walkden-Moor; from which mines, by these navigations above-ground and under-ground, Manchester and various other places are supplied with that valuable article.

The canals of this under-ground navigation lie upon two levels, or stories.

The lower is upon the same level with the open navigation, which it joins at Worsley; and consists, in the different lines which it pursues to the different seams of coal, of near twelve miles of tunnelling.

The higher is thirty-five yards and a half perpendicular height above the level of the lower, and varies from thirty-eight to sixty-one perpendicular yards below the surface of the earth, and consists of near six miles of tunnelling.

The tunnelling of each level is ten feet four inches wide, and eight feet six inches deep; and the depth of water, three feet seven inches.

Before a communication was made by an inclined plane, the

* *Forty miles upon one level.*] Adding to these forty miles, nearly twelve miles of the Duke of Bridgewater's Under-ground Navigable Canal, which lie upon his lower main level, and including eighteen miles of the Grand Trunk Canal betwixt the lowest lock between Middlewich and Preston-brook, there are seventy miles of navigable canal, without a lock, upon one level, eighty-two feet above low-water mark; whereby a communication is obtained between London, Liverpool, Bristol, and Hull. At this lowest lock the Grand Trunk Navigation locks down, to be upon a level with the Duke of Bridgewater's.

the coals were difcharged by hand from the boats on the higher level, and were let down the pits in tubs by an engine and a break-wheel into thofe upon the lower. To convey the boats themfelves from the canals of the higher level into that of the lower, was the intent of making this under-ground inclined plane. By the help of this machinery, the whole bufinefs is now done at once, without difcharging or damaging the coal, and at one fourth of the expenfe: for the boats of the higher level are bodily let down the inclined plane, and are floated from the foot of it through nearly three miles, in a ftraight line, of the lower level canal, into the open navigation at Worfley: and, whereas they were before obliged to be drawn up to the furface of the earth at great inconvenience and expenfe, to be repaired at a work-fhop on Walkden-Moor, they now come of themfelves, in their courfe of bufinefs, to be repaired at the great dock-yard at Worfley.

The place where the inclined plane is conftructed, is adapted in a fingular way for the purpofe. There is a bed of white rock, or grit, eight yards twelve inches deep, which dips one in four, lying exactly in the direction moft convenient for the communication between the two levels; which bed of rock is hollowed into a tunnel, driven upon the rife of the metals, by blafting with gun-powder, and working it down with wedges and hammers. In this tunnel, formed through a rock reaching from the lower to the higher level, the inclined plane is fixed; and, by its being in the heart of a rock, the whole workmanfhip can be pinned, fecured, and compacted together at the top, bottom, and fides, moft effectually:—an advantage which no inclined plane above-ground can have, and which renders this a fingular production, no where perhaps to be imitated.

The run of the inclined plane is one hundred and fifty-one yards, befides eighteen yards, the length of the locks, at the north or upper end: and the fall is one in four, correfponding with the dip of the rock.

Of thefe one hundred and fifty-one yards, about ninety-four yards are formed into a double waggon-way, in order to let two boats, namely, the empty and the loaded boat, pafs up and down; and are divided by a brick wall, fupporting the roof, in which are openings for a perfon to efcape out of the way of the boats; which double waggon-way joins in one, about fifty-feven yards from the lower level.

The whole width of the double waggon-way is nineteen feet; and of the fingle waggon-way, after the junction, ten feet.

Thefe waggon-ways are fupplied with iron rails, or gullies, laid on fleepers, down the whole run; and the height of the roof, above the iron rails, is eight feet.

At the top of the inclined plane there is a double lock, or rather two locks, fide by fide, formed in the heart of the fame rock, which deliver the loaded boats from the higher level down the inclined plane, and receive the empty boats from the lower. The length of that part of the tunnel in which thefe are formed, is eighteen yards; the width or diameter, twenty feet fix inches; and the height of the roof, at the north end and above the locks, at *d d*, Plate I. fig. 4. twenty-one feet, to admit the break-wheel.

The bottom, or fouth end of the inclined plane, is fix feet nine inches under the furface of the water, where the loaded boat floats off the carriage upon the canal of the lower level.

The depth of the locks, under water, at the north end, is four feet fix inches; at the fouth end it is eight feet.

The wall between the locks is nine inches above the furface of the level water; its breadth is three feet.

The diameter of the horizontal main-fhaft, upon which the rope works to let the loaded boats down, and to draw the empty boats up, is four feet eleven inches, and its circumference is fifteen feet five inches. The main-rope is two inches and a half in diameter, and feven inches and a half in circumference. It is lapped round with a fmall cord of about an inch in circumference, for the length of about one hundred and five yards, to prevent its wearing, which it does chiefly when it drags upon the bottom, when at work, at the place where the waggon-ways unite; and, for the fame purpofe, rollers of eight inches diameter are fixed at intervals down the run of the inclined plane. Moreover, a hollow

caft-caſt-iron roller of eight inches and a half diameter is fixed acroſs the weſt lock, parallel to the upper weſt lock-gate, and near the north end of the lock, but half a yard higher than the gate, in order to bear up the rope, and to prevent it from ſwagging.

A hold-faſt rope is faſtened to the main-rope, to ſtay each boat upon its waggon, as they go up or down. It is marked *k k*, in fig. 4, Plate I. and its uſes are more particularly detailed in the table of reference, at *k k*, to that plate.

Upon this horizontal main-ſhaft is a break-wheel above mentioned, which regulates the motion of the loaded boat going down the inclined plane.

The number of iron teeth, or cogs, in the ſpur-wheel, which is faſtened to the ſide of the break-wheel, is three hundred and ſeventy-two; and the little nut-wheel, No. 3, fig. 5. which ſets it in motion, contains eleven teeth, or cogs. The nut-wheel is ſupported by two uprights from the pillar to the roof, and works between them. Two winches or handles, No. 4 4, fig. 5, on its axis, put the main-ſhaft, *d d*, fig. 4. or No. 1, fig. 4. in motion. The power of both united enables a man, who uſes a force equal to forty pounds weight, to ſet forward two tons upon the waggon-road: and this force, multiplied at the winches or handles, may be uſed to ſet forward the loaded boat out of one lock, and to bring the empty boat into the other. The boats being thus put in motion, the little nut-wheel is diſengaged from the main-ſhaft, by a ſlide drawing the little nut ſideways, ſo as to diſengage the teeth, or cogs, from the cogs of the ſpur-wheel. The weight of four tons going down brings up about one.

The ſpur-wheel, however, which is faſtened to the break-wheel, No. 2, fig. 5. is ſeldom uſed, as it is occaſionally only put in motion to regulate the ſtretch of the ropes when new, and to draw the light boat into the lock, when at any time it may happen to be over-weighted with materials, ſuch as mortar, props, ſlabs, &c. for the uſe of the higher level collieries, and will not move of itſelf, upon a balance, out of the lower level.

The length of the carriage, or cradle, is thirty feet; its

 width

width is ſeven feet four inches. It moves upon four ſolid caſt-iron rollers, which run upon caſt-iron plates; on one ſide of each of which there are iron creſts, which ſtand two inches higher than the plates, and prevent the carriage from running off the road.

The weight of neat coal, contained in the loaded boat, is about twelve tons: the boat weighs about four tons; and the carriage, or cradle, in which the boat is placed, when conveyed down the inclined plane, is about five tons:—in all about twenty-one tons.

At this inclined plane, thirty loaded boats are now let down, with eaſe, in about eight hours; that is to ſay, four boats are let down in a little more than an hour. The boats uſed in theſe collieries are of different ſizes and dimenſions; ſome will carry ſeven, ſome eight and a half, ſome twelve tons.

The weight of neat coal, independently of the weight of the carriage and boats, which is let down the inclined plane, in twelve-ton boats, in eight hours, will conſequently be three hundred and ſixty tons. The weight of the carriage, ſuppoſe five tons, let down in the ſame time, will be one hundred and fifty tons; and the weight of the boat, ſuppoſe four tons, thirty times down, in eight hours, will be one hundred and twenty tons:—in all ſix hundred and thirty tons down in eight hours.

The weight of the carriage thirty times up, and thirty boats up, in eight hours, will be

Carriage, at 5 tons, 30 times up = 150 tons
Boat, at 4 tons, 30 times up = 120 tons

In all 270 tons up in eight hours.

So that there will be 630 tons down
270 tons up

In all 900 tons moved at the inclined plane, in 8 hours, excluſive of an indeterminate quantity of materials occaſionally brought up for the uſe of the higher level collieries.

The

The various feeders which are loofened by opening the coals in the higher level collieries, as well as three fufficient refervoirs, which may occafionally be reforted to, and ufed in a dry feafon, keep the higher level always to its height, and afford a conftant fupply of water to fill the locks, for the purpofe of working the inclined plane.

This inclined plane was begun in September, 1795; it was finifhed, and in ufe, in October, 1797.

Of this, as of moft of his other great works, the Duke of Bridgewater was himfelf the planner and contriver :—to project greatly, and to execute completely, are the perfection of genius.

The fingularity of the place in which it is conftructed; the original boldnefs of the defign; the ingenuity and mechanifm difplayed in planning and executing it; the difpatch with which it has been finifhed; the fimplicity, beauty, and harmony of its parts, tending to one united whole; and, above all, the perfection to which it is proved to have been brought, now that it is practically in ufe; render it equally aftonifhing with any other of the ftupendous works which have been fo ably planned, and fo fuccefsfully executed, by the firft projector and patriotic father of Inland Navigation.

I have the honour to be, &c.

FRANCIS H. EGERTON.

Bridgewater-Houfe,
March 5, 1800.

*References to the Plate.*

*a* to *b*, (Fig. 4.) Dip of the metals and waggon-road on the under-ground inclined plane. From *b*, on the lower level, to the mouth of the tunnel, is three miles. A, The eaft lock. B, the weft lock. C, reprefents a fection of the lock: the dotted line fhows the horizontal depth, and the black line under it, the flope upon which the waggon wheels run to receive the loaded boat, or to bring the empty boat into the lock. *d d*, the main-fhaft, four feet eleven inches diameter, upon which the ropes work to wind the boats up and down; and here alfo the break-wheel is faftened on, together with a fpur-wheel, and a nut-wheel. See fig. 5, No. 1. *e*, a paffage betwixt the higher level and the locks. *f f*, a loaded

loaded boat going down, and an empty boat going up the under-ground inclined plane. G, a brick wall from the ſole to the top of the inclined plane, in order to give additional ſupport to the roof. *h h h h*, openings through the brick wall G, into which a perſon may ſtep out of the way of the boats, at the time they are paſſing up and down. *i*, a bell, which is rung by the rope dotted to *b*, upon the lower level, at the bottom of the under-ground inclined plane, to give notice when the empty boat is upon the waggon, or cradle, and when the men below are ready, that the loaded boat may be let down by the men above. *k k*, Holdfaſt-ropes faſtened to the main-ropes, and hooked on to a ring at the ſouth end of each boat, as it goes up or down, in order to ſtay the boats upon the waggon or cradle, that they may not ſwag, or ſlip off. Theſe holdfaſt-ropes are ſpliced on to the end of the main-ropes, and run above and between the two bridle-ropes when they are faſtened to the iron uprights, which are upon each ſide of the waggons, or cradles; and they run over the north end of the boat, to be hooked on to the ſouth end. *l l*, the bridle-ropes faſtened to the main-ropes at O, and ſecured to two iron uprights upon each ſide of the waggon, or cradle. O O, the places where the main-ropes, the bridle-ropes, and the holdfaſt-ropes, are faſtened all together. No. 1. An open ſpace driven into the ſide of the lock A, to which a pit is ſunk from the higher level, in order to convey the water out of the locks down to the lower level, and alſo to force a current of freſh air into the lower level collieries. No. 2. A paddle to let the water out of the lock A, into the pit No. 1. No 3. A paddle to let the water out of the lock B, through a culvert, repreſented by dotted lines, under the lock A, into the pit No. 1. No. 7, 7. Paddles in the lock-gates, to let the water out of the higher level into the locks. No 8, 8. The two north lock-gates, one to each lock, which turn upon the heels of the gates, and ſwing round when they are opened or ſhut. No. 10, 10. Two ſtops or cloughs, one to each lock, which ſerve as lock-gates to the ſouth end, and are raiſed and let down by a windlaſs. S, a ſtop, which is uſed occaſionally when the lock-gates want repairing. T, the place where the boats which are to paſs

to

to or from the lower single waggon-way are directed, at pleasure, into either part of the double waggon-way, by a moveable iron sleeper or plate at that point, upon which sleeper or plate the wheels of the boat-carriage or cradle run. No. 1. (fig. 5.) main-shaft on which the rope laps. 2. Break-wheel, on one side of which the spur-wheel is fastened. 3. Nut-wheel, out of geer, but which slides into the spur-wheel, when used to draw the empty boat into the lock occasionally, and which is supported by two uprights from the pillar to the roof. 4, 4. Winches or handles, to work the nut and spur-wheel. 5, 5. The main-ropes fastened to the boats, and which are lapped to prevent their wearing. 6. The spur-wheel, which is fastened on one side of the break-wheel; and on which break-wheel is a strong iron-jointed timber brace, which, according to the pressure given thereto by the man who attends it, will allow the loaded boat to descend quick or slow, or detain it in its passage. 7, 7. Paddles in the lock-gates, to let the water out of the higher level into the lock. 8. A hollow cast-iron roller, to prevent the main-ropes from swagging. 9. Shroud-wheel, to prevent the ropes going over the end of the main-shaft, slipping off, jerking, or breaking. This stands three inches above the main-shaft.

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## V. *Dr.* Dickson's *Translation of* Carnot *on the Infinitesimal Calculus.*

[Concluded from Vol. VIII. Page 352.]

### *The Principles of the Differential and Integral Calculi.*

49. If to the same variable quantity be successively attributed two values whose difference is infinitely small, that difference (*viz.* that of the second, from the first of the two values) is called the *Differential* of the first value.

For example, let *AMN* (fig. 2.) be a curve, concerning which any question whatever is to be resolved, and such that the ordinate *MP* is one of the quantities assigned in that question. I suppose, moreover, that, to facilitate the solution, an auxiliary line *NQ* is drawn parallel to, and at an arbitrary diſtance from, the ordinate *MP*, to which it (*NQ*) may continually approach, till the two lines coincide; the line *NO*, or *NQ* — *MP* will then be an infinitely ſmall quantity (ſee art. 19). Now as *NO* is the difference of the two values, *MP* and *NQ*, ſucceſſively attributed to the ordinate, it has been agreed to diſtinguiſh it in diſcourſe by the diminutive word, the *differential*, of the variable line *MP*, and to repreſent it in calculation by the ſame variable line, with the character *d* prefixed *. Thus, putting *y* for the ordinate *MP*, *dy* will ſignify the Differential of *MP*.

But to ſuppoſe, as we have done, that *NQ* continually approaches *MP*, is alſo to ſuppoſe that *AQ* continually approaches to *AP*; for the firſt of theſe ſuppoſitions neceſſarily implies the ſecond. Putting, therefore, *x* for the abſciſſe *AP*, the little line *PQ* or *MO* will be the differential of *x*, and we ſhall have $MO = dx$ in the ſame time that $NO = dy$.

If we farther ſuppoſe $NQ = y'$, and $AQ = x'$, we ſhall have $y' = y + dy$, and $x' = x + dx$; ſo that the differentials *dy* and *dx*, are nothing elſe than the increments of their correſpondent variables *y* and *x*, or the quantities by which they are increaſed when they become $y'$ and $x'$ †.

50. Now, let there be attributed to the ordinate a new value *RS*, ſuch that *PQ* and *QS* may differ infinitely little from

* Here one is almoſt tempted to aſk, Whether the ingenious author conſiders the Britiſh mathematicians as mere *Differentials*? For they have never agreed to uſe the notation he mentions; but, inſtead of $dx$, $dx\,dy$, &c. write, with Newton, the immortal inventor of fluxions, $\dot{x}$, $\dot{x}\dot{y}$ &c. The *d's* only ſerve to embarraſs the combinations, which ſhould be expreſſed with the utmoſt clearneſs. W. D.

† The author, after partly explaining the doctrine of prime and ultimate ratios, ſeems to decline applying that doctrine, when he calls *dx* and *dy* mere increments. It may, however, be obſerved that, had he conſidered them in their extreme ratios, he would have entirely deviated from the infiniteſimal or differential theory, which is properly his ſubject, into the fluxionary. But, as already hinted, his mixed way of elucidating his doctrine, may be of great uſe, if his readers take care not to confound the differentials (or increments) of quantities conſidered as formed by an appoſition of parts, with the fluxions, which are accurately in the prime ratio of the naſcent, or the ultimate ratio of the evaneſcent, increments (or decrements) of quantities, conſidered as generated by motion.—W. D.

from each other, or have for their ultimate ratio, a ratio of equality. This being so, it must necessarily happen (because *NQ*, by the first hypothesis, is already supposed to approach continually to *MP*) that *RS* will also continually approach to the same line *MP*; so that, like *NQ*, it will ultimately coincide with that same line; otherwise it is evident that the ratio of *QS* to *PQ*, which, by the supposition, ought to approach continually to unity, would recede from it. It is moreover evident, from the law of continuity, that the same will be the case with the ratio of *RZ* to *NO*. Agreeably, therefore, to the general notion of differential quantities, above delivered, *QS* ought to be the differential of *AQ*, *RZ* that of *NQ*, $QS - PQ$, or $NZ - MO$, that of *PQ*, and lastly, $RZ - NO$, that of *NO*; and all for the same reason that *NO*, or $NQ - MP$, is the differential of *MP*. According to the received manner, then, of expressing differentials in calculation, we must have $QS = dx$, $RZ = dy$, $QS - PQ = d(MO)$, $RZ - NO = d(NO)$. But we have already found $MO = dx$, and $NO = dy$; therefore $QS - PQ = ddx$, and $RZ - NO = ddy$, that is, the quantities $ddx$ and $ddy$ (also written $d^2x$ and $d^2y$) will be the differentials of the differentials of $x$ and $y$, called also, for brevity, *second differences*, or *differentials of the second order*; that is, $ddx$ is the differential of the second order, or the second difference of $x$, and $ddy$ that of $y$.

Now, since *QS* and *PQ* are supposed to differ infinitely little from each other, their difference $ddx$ is infinitely small in comparison with each of them (by article 28). Therefore differentials of the second order are infinitely small in comparison with first differentials, or those of the first order *.

51. In the same manner may be *differentiated*, in their turn,

* If, instead of drawing the new auxiliary line *RS* in such manner that the lines *QS* and *PQ* differ infinitely little from each other, it be drawn in such a manner that *QS* may be precisely equal to *PQ*, that is, so that *AP*, *AQ*, and *AS* may be in arithmetical progression, we shall have $ddx = 0$, or $dx$ constant. Thus, one of the differentials may be supposed constant. But, from *AP* *AQ* and *AS* being in arithmetical progression, it will not follow that *MP*, *NQ* and *RS* are so likewise, unless *AMN*, instead of being a curve, be a straight line. Thus, from the supposition that $ddx = 0$, it can by no means be inferred that $ddy = 0$.

the differentials of the second order, and hence will result the differentials of the third order; from the *differentiation* of these last will result those of the fourth order, and so on. Thus $dddy$, or $d^3y$ will be the third difference of $y$ and $ddddy$, or $d^4y$, the differential of the fourth order, &c. Now, after what has been said on the generation of differentials of the first and second orders, there will be no difficulty in comprehending the production of the superior orders. I shall therefore only observe, that it consists in attributing, for each new order, a new auxiliary value to each of the variable quantities, and such, that not only each of these new values may differ infinitely little from that which precedes it, but that the same thing may take place between their differentials, the differentials of their differentials, and so forth.

52. To *differentiate* a quantity is to assign its differential; that is, if $X$, for example, be any function whatever of $x$, to differentiate it, is to assign the quantity by which that function will be increased, by supposing the increment of $x$ to be $dx$.

To *integrate*, or to *sum*, a differential, on the contrary, is to return from that differential to the quantity which produced it; and this last quantity is called the *Integral* or *Sum* of the proposed differential *. For example, $x$ is the integral or sum of $dx$, and to integrate, or to sum, $dx$ is nothing more than to assign that quantity, $x$, which is its sum or integral.

We have seen that, in calculation, the differential of a quantity is expressed by that same quantity, with the character $d$ prefixed. Reciprocally it has been agreed to express the integral or sum of any differential by the same differential, preceded by the character $\int$; that is, $\int dx$, for example, signifies the sum of $dx$; so that we have evidently $x = \int dx$.

53. The *Calculi* called *Differential* and *Integral*, constitute the art of discovering any ratios and relations whatever, existing between proposed quantities, by the help of their differentials. The name *Differential Calculus* is properly applied to the art of investigating the ratios, or relations of differential quantities, and afterwards to eliminate them by the ordinary rules of Algebra; and the name of *Integral Calculus* to the art of integrating or eliminating these same

* Or what we call the *Fluent* of the proposed *Fluxion*.—W. D.

differential

differential quantities by processes which show the method of returning from a differential to its integral.

*My present object is not to write a treatise on these calculi, but only to give the fundamental rules, and to show that these rules are only so many applications of the general principles which have been explained.*

54. Let it first be proposed, then, to assign the differential of the sum, $x + y + z$ &c. of several variable quantities.

By the hypothesis, $x$ becomes $x + dx$, $y$ becomes $y + dy$ &c. Therefore the sum proposed becomes $x + dx + y + dy + z + dz$ &c. Consequently, it is increased by $dx + dy + dz$, &c.; and these increments are precisely what we have called differentials *.

55. The differential of $a + b + c$ &c. $+ x + y + z$ &c. is now required; $a, b, c$, &c. being constant, and $x, y, z$, &c. variable, quantities.

By the hypothesis $a$ remains $a$, $b$ remains $b$, &c. and $x$ becomes $x + dx$, $y$ becomes $y + dy$ &c. Therefore the sum proposed becomes $a + b + c$ &c. $+ x + dx$ &c. Consequently it is increased by $dx + dy + dz$ &c.; and this increment is the differential sought, which is the same as if there had been no constant quantities in the proposed sum.

Required the differential of $ax$.

By the hypothesis, the constant quantity $a$ remains unchanged, and the variable quantity $x$ becomes $x + dx$; therefore $ax$ becomes $ax + adx$; and consequently $ax$ is increased by $adx$, which is the differential sought.

56. Required the differential of $xy$.

From what has been said, it appears that the differential here required is $ydx + xdy + dxdy$, that is, we have

$$d\,.\,xy = ydx + xdy + dxdy\ \dagger.$$

But,

* See the note at the end of article 49.

† As the ingenious author has touched no farther on the practice than seemed necessary to elucidate his theory, I shall endeavour to show (*as plainly as I can in a note*) how to find the differentials, or, which is the same thing in practice, the fluxions of products, powers, roots, and fractions.

1st, To find the fluxions of products, such as $xy$, $xyz$, &c.

*Example* 1. $(x + \dot{x}) \times (y + \dot{y}) = xy + x\dot{y} + y\dot{x} + \dot{x}\dot{y}$.



But,

But, with respect to this equation, I observe, that $dx$ and $dy$, being infinitely small, in comparison with $x$ and $y$, the last

But, for a reason which the author gives, $\dot{x}\dot{y}$ (in his notation $dxdy$) may be rejected, and so the fluxion of $xy$ is $x\dot{y} + y\dot{x}$.

*Example* 2. Thus also, the fluxion of

$$xyz \text{ is } xz\dot{y} + yz\dot{x} + xy\dot{z}.$$

*Example* 3. In like manner, the fluxion of

$$vxyz \text{ is } vxy\dot{z} + vxz\dot{y} + vyz\dot{x} + xzy\dot{v}.$$

2dly, To find the fluxions of powers, as $x^2$, $x^3$, &c.

*Example* 1. In the first example above, we had $x\dot{y} + y\dot{x}$ for the fluxion of $xy$. Let $x = y$, then $xy = x^2$, and $x\dot{y} + y\dot{x} = x\dot{x} + x\dot{x}$ or $2x\dot{x}$, will be the fluxion of $x^2$.

*Example* 2. In the second example above, let $x = y = z$ then $xyz$ will become $x^3$, and $xy\dot{z} + xz\dot{y} + yz\dot{x}$ will become $xx\dot{x} + xx\dot{x} + xx\dot{x}$, or $3x^2\dot{x}$, which will be the fluxion of $x^3$.

*Example* 3. In like manner, if, in the 3d example above, $v = x = y = z$, the fluxion of $x^4$ will be $4x^3\dot{x}$.

Thus the fluxion of $x^2$ being $2x\dot{x}$, that of $x^3$ being $3x^2\dot{x}$, that of $x^4$ being $4x^3\dot{x}$, &c. we conclude that the fluxion of any power of $x$ whatever, say $x^m$, will be $mx^{m-1}\dot{x}$. Here the index $m$ is supposed to be integral and affirmative; but the same formula, *mutatis mutandis*, serves where $m$ is fractional or negative.

3dly, Before we proceed to powers whose indices are negative, it will be necessary to contemplate very attentively such series as

$$x^4,\ x^3,\ x^2,\ x^1,\ x^0,\ \frac{1}{x^1},\ \frac{1}{x^2},\ \frac{1}{x^3},\ \frac{1}{x^4},\ \&c.$$

$$\text{or, } x^4,\ x^3,\ x^2,\ x^1,\ x^0,\ x^{-1},\ x^{-2},\ x^{-3},\ x^{-4},\ \&c.$$

where the law of continuation of the powers is a successive division by $x$, and that of the indices a successive subtraction of 1; so that $x^{-1}$, $x^{-2}$, &c. in the second series, is equivalent to $\frac{1}{x}$, $\frac{1}{x^2}$, &c. in the first; or, in other words, the negative indices $-1$, $-2$, &c. of $x^{-1}$, $x^{-2}$, &c. considered as multipliers, are equivalent to the positive indices 1, 2, &c. of $\frac{1}{x^1}$, $\frac{1}{x^2}$, &c. considering $x^1$, $x^2$, &c. as divisors. Hence the general formula, $mx^{m-1}\dot{x}$, becomes $-mx^{-m-1}\dot{x}$, or $\frac{m\dot{x}}{x^{m+1}}$; and thus the fluxion

of

last term $\dot{x}\dot{y}$ is itself infinitely small in comparison with each of the others; that is, that the quotient of this last term by either of the other terms is an infinitely small quantity. If, therefore,

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of $\frac{1}{x}$, or of $x^{-1}$, is $-1x^{-2}\dot{x}$, or $\frac{-\dot{x}}{x^2}$;

of $\frac{1}{x^2}$, or of $x^{-2}$, is $-2x^{-2-1}\dot{x}$, or $\frac{-2\dot{x}}{x^3}$;

of $\frac{1}{x^3}$, or of $x^{-3}$, is $-3x^{-3-1}\dot{x}$, or $\frac{-3\dot{x}}{x^4}$;

of $\frac{1}{x^4}$, or of $x^{-4}$, is $-4x^{-4-1}\dot{x}$, or $\frac{-4\dot{x}}{x^5}$; and so of others.

4thly, Before we can find the fluxions of powers with fractional indices, commonly called roots, we must very attentively consider the law of continuation in such series as

$x^4$, $x^2$, $x^1$, $x^{\frac{1}{2}}$, &c. continually extracting the square root,

$x^9$, $x^3$, $x^1$, $x^{\frac{1}{3}}$, &c. ———————— the cube root,

$x^{16}$, $x^4$, $x^1$, $x^{\frac{1}{4}}$, &c. ———————— the biquad. root,

$x^{\frac{9}{3}}$, $x^{\frac{3}{2}}$, $x^{\frac{1}{1}}$, $x^{\frac{2}{3}}$, &c. ———————— cube root of the square.

Here we see that it is not more than certain that $x^2$ is the square root of $x^4$, or $x$ the square root of $x^2$, than that $x^{\frac{1}{2}}$ is the square root of $x$. And, by the same law that $x^3$ is the cube root of $x^9$, and $x$ the cube root of $x^3$, we may affirm, that $x^{\frac{1}{3}}$ is the cube root of $x$, &c. Thus, then, we may safely write $x^{\frac{1}{2}}$ for $\sqrt{x}$, $x^{\frac{1}{3}}$ for $\sqrt[3]{x}$, $x^{\frac{2}{3}}$ for $\sqrt[3]{x^2}$, &c. and universally, $x^{\frac{m}{n}}$ for $\sqrt[n]{x^m}$. This being understood, it will be evident that the general formula, $mx^{m-1}\dot{x}$, by writing $\frac{m}{n}$ for $m$, must become $\frac{m}{n}x^{\frac{m}{n}-1}\dot{x}$, or $\frac{m}{n}x^{\frac{m-n}{n}}\dot{x}$. And hence the fluxion

of $\sqrt{x}$, or $x^{\frac{1}{2}}$, is $\frac{1}{2}x^{\frac{1}{2}-1}\dot{x} = \frac{1}{2}x^{-\frac{1}{2}}\dot{x} = \frac{\dot{x}}{2x^{\frac{1}{2}}}$;

of $\sqrt[3]{x}$, or $x^{\frac{1}{3}}$, is $\frac{1}{3}x^{\frac{1}{3}-1}\dot{x} = \frac{1}{3}x^{-\frac{2}{3}}\dot{x} = \frac{\dot{x}}{3x^{\frac{2}{3}}}$;

of

therefore, $dxdy$ be neglected in the preceding equation, it will then become $d.xy = xdy + ydx$, which is what I call an imperfect equation. But, since imperfect equations (by articles 31 and 34) may be employed like rigorous ones, without inducing any error into the result, it is evident that I may use this last equation instead of the first; and, as it is more simple, I shall by its help abridge my calculation.

I say, then, that the differential of the product of two variable quantities, is equal to the product of the first variable quantity into the differential of the second, *plus* the product of the second variable quantity into the differential of the first. And this proposition will be one of those which (in article 35) I have called imperfect propositions, that is, which are capable of being expressed by imperfect equations, and

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of $\sqrt[4]{\ }$, or $x^{\frac{1}{4}}$, is $\frac{1}{4}x^{\frac{1}{4}-1}\dot{x} = \frac{1}{4}x^{-\frac{3}{4}}\dot{x} = \frac{\dot{x}}{4x^{\frac{3}{4}}}$;

of $\sqrt[3]{x^2}$, or $x^{\frac{2}{3}}$, is $\frac{2}{3}x^{\frac{2}{3}-1}\dot{x} = \frac{2}{3}x^{-\frac{1}{3}}\dot{x} = \frac{2\dot{x}}{3x^{\frac{1}{3}}}$;

and so in similar cases.

5thly, The fluxion of a fraction may be found by considering it as the product of the numerator and denominator, giving the latter a negative index. Thus $\frac{x}{y}$ is equivalent to $y^{-1} \times x$; and as the fluxion of $xy$ is $y\dot{x} + x\dot{y}$, so the fluxion of $\frac{x}{y}$, or of its equivalent $y^{-1} \times x$ must be,

$$(y^{-1} \times \dot{x}) + (-y^{-2}\dot{y} \times x) = \frac{\dot{x}}{y} - \frac{x\dot{y}}{y^2} = \frac{y^2\dot{x} - yx\dot{y}}{y^3}$$

$$= \frac{y\dot{x} - x\dot{y}}{y^2}.$$

The fluxion of a fraction, $\frac{x}{y}$, may also be found, but not so elegantly, by actually dividing $x + \dot{x}$ by $y + \dot{y}$.

The above is a specimen of a very easy, and, in some measure, new, manner of treating the fundamental processes of fluxions, which I long ago mentioned to Mr. Tilloch, and which, with some thoughts on prime and ultimate ratios, I intend to offer him for publication, when I have time to draw up the paper, and he has room to insert it in the Philosophical Magazine.—W. D.

which,

which, like them, lead, neverthelefs, to refults rigoroufly exact *.

57. By proceeding as in the laft article, we fhall find the imperfect equation

$$d\,.\,xyz = xydz + xzdy + yzdx.$$

In like manner we fhall find the imperfect equation $d.x^m = mx^{m-1}dx$ &c.

And, by the fame kind of procedure, we difcover the imperfect equation $d\,.\,\frac{x}{y} = \frac{ydx - xdy}{yy}$.

58. Such are the principal rules of the Differential Calculus. Let us now proceed to thofe of the Integral Calculus, which is the Inverfe method †.

1. Since

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* If from the imperfect equation $d\,.\,xy = xdy + ydx$, I wifhed to derive a rigoroufly accurate equation, I might do it at once, by reftoring the term $dxdy$, which it wants. But I might alfo effect it in the following manner. Dividing the preceding equation by $dy$, for example, I obtain the new imperfect equation $\frac{d\,.\,xy}{dy} = y\frac{dx}{dy} + x$; and as (by article 19) an auxiliary quantity differs infinitely little from its *limit*, I may fubftitute in this laft equation $lim.\left(\frac{d\,.\,xy}{dy}\right)$ inftead of $\frac{d\,.\,xy}{dy}$ itfelf, and $lim.\left(\frac{dx}{dy}\right)$ inftead of $\frac{dx}{dy}$ itfelf. Now, it thence becomes $lim.\left(\frac{d\,.\,xy}{dy}\right) = y \times lim.\left(\frac{dx}{dy}\right) + x$. But every limit is (by article 17) an affigned quantity; therefore, though $dx$ and $dy$ are, themfelves, auxiliary quantities, $lim.\left(\frac{d\,.\,xy}{dy}\right)$ and $lim.\left(\frac{dx}{dy}\right)$ are affigned quantities. All the terms, therefore, of the preceding equation, $lim.\left(\frac{dxy}{dy}\right) = y \times lim.\left(\frac{dx}{dy}\right) + x$, are affigned quantities; and confequently (by article 34) this equation is neceffarily and rigoroufly exact.

† The author touches the practice of the Integral Calculus as flightly as he does that of the Differential; but the former does not fo directly bear on his fubject as the latter; and, if it did, I could not expect to be indulged with fo long a note as I have given on the other; and which, after all, is but a flight and imperfect general outline. For particular inftructions, the reader, who is acquainted with the neceffary *præcognita*, muft

1. Since the differential of $x$ is $dx$, the integral of $dx$ will be $x$; that is, we ſhall have $\int dx = x$. But, as the differential of $a + x$ is alſo $dx$ (by article 55) it follows that the integral of $dx$ is as juſtly expreſſed by $a + x$, as by $x$ alone; and that, in general, every differential hath as many various integrals as we may chooſe to aſſign to it; but that all theſe integrals only differ by a conſtant quantity. It ſuffices, therefore, to determine one of them, and to add ſome conſtant quantity to repreſent all the reſt; that is, all the poſſible integrals of $dx$ will be repreſented by $x + A$, the quantity $A$ being a conſtant quantity, taken at pleaſure.

2. Becauſe the differential of $x + y + z$ &c. is $dx + dy + dz$ &c. the integral of this differential will be $x + y + z$ &c. $+ A$.

3. The differential of $xy$ being $xdy + ydx$ (by article 56) as well as that of $xy + A$, the integral of $xdy + ydx$, will be reciprocally $xy + A$.

4. In like manner, we ſhall find the integral of $\frac{ydx - xdy}{yy}$ to be $\frac{x}{y} + A$.

5. So likewiſe we ſhall find that the integral of $mx^{m-1}dx$, is $x^m + A$, &c.

Such are the principal rules of the Integral Calculus. We proceed to ſhow, by ſome particular examples, the application of theſe rules, and of thoſe of the Differential Calculus: both which we ſhall do as ſuccinctly as poſſible.

*Application of theſe general Principles to ſome Examples.*

59. An elliptic curve $AMB$ (fig. 3.) being given to find

muſt have recourſe to more extenſive works, ſuch as the Fluxions of Simpſon, Emerſon or Maclaurin, and above all, thoſe of Ditton or L'Hoſpital, as tranſlated and augmented by Stone; which two laſt, eſpecially Ditton's, are generally conſidered as the plaineſt works on the ſubject. The perſpicuity of Simpſon's excellent tract, in his Select Mathematical Exerciſes, has been already mentioned. The ſame excellent quality pervades the ſix Diſſertations on the progreſs of Geometry, inſerted in "The Mathematician," printed in 1751, of which the three laſt are confined to Fluxions.—W. D.

the subtangent $TP$, answering to $M$, which represents any given point whatever of that curve.

Let $AB$ be the transverse axis of the curve, for one half of which put $a$; and for one half of the conjugate put $b$; and let $x$ represent the abscis $AP$, and $y$ the ordinate $PM$. We shall then have,

$$yy = \frac{bb}{aa}(2ax - xx).*$$

This being laid down, let a new ordinate $NQ$ be drawn infinitely near to $MP$; that is, let this auxiliary line $NQ$ be at first drawn at any arbitrary distance whatever from $MP$, and let the former then be supposed to approach the latter continually, so that their ultimate ratio may be a ratio of equality. The lines $MO$ and $NO$ will then be the respective differentials of $x$ and $y$ (by article 49). Now the similar triangles $TPM$ and $MZO$, give $\frac{TP}{MP} = \frac{MO}{ZO} = \frac{MO}{NO + ZN}$. But it is evident, that the more $NQ$ approaches to $MP$, the more will $ZN$ diminish in comparison with $NO$, and that their ultimate ratio will be 0. Therefore $ZN$ is infinitely small compared with $NO$; and consequently $\frac{TP}{MP} = \frac{MO}{NO}$ is an imperfect equation (by article 31); that is, $\frac{TP}{y} = \frac{dx}{dy}$ is an imperfect equation.

Farther, the equation of the proposed curve being,

$$yy = \frac{bb}{aa}(2ax - xx),$$

we shall thence have this other imperfect differential equation,

$$ydxy = \frac{bb}{aa}(adx - xdx).$$

In this last equation, then, substituting the value of $dx$, namely, $\frac{TP \cdot dy}{y}$, found by the first, and reducing, we have

$$\text{the required subtangent } TP = \frac{aa}{bb} \times \frac{yy}{a - x},$$

an equation free from infinitesimal quantities, and which is necessarily and rigorously accurate.

* For, in the ellipse, $a^2 : b^2 :: (2a - x) . x : y^2$.—W. D.

60. *Otherwise:* Let us consider the proposed curve as a polygon of an infinite number of sides; that is, instead of the curve, let us take a polygon of any number of sides whatever, and let us then suppose that number of sides to increase continually; so that the ultimate relation of the polygon to the curve may be a relation of identity *. As it is absolutely impossible that the curve can be accurately considered as a polygon, the equations by which I shall express the conditions of the problem depending on that hypothesis will not be exact. But, since the polygon is supposed to approach continually to the curve, the errors, which may exist in these equations, may be diminished as much as we please; and hence these equations will be what I call imperfect equations.

Thus the triangles $T'MP$ and $MNO$ give the equation $\frac{T'P}{MP} = \frac{MO}{NO}$; and substituting $TP$ for $T'P$, which differs infinitely little from it, we shall have this imperfect equation $\frac{TP}{MP} = \frac{MO}{NO}$, or $\frac{TP}{y} = \frac{dx}{dy}$, the same with that before found, and which, being combined with the equation of the curve, will give the same result.

61. *Again:* We may apply to this problem the method of indeterminates, without making any alteration in the process. After finding the two imperfect equations,

$$\frac{TP}{y} = \frac{dx}{dy}, \text{ and } 2ydy = \frac{bb}{aa}(2adx - 2xdx),$$

I add mentally the quantity $\Phi$ to one of the sides of the first equation, in order to render it rigorously exact; and I introduce, in like manner, into the second, a quantity $\Phi'$, which renders it equally accurate. The quantities thus understood, namely $\Phi$ and $\Phi'$, are therefore infinitely small compared with those to which they are mentally added. This being settled, I compare the two preceding equations, without having any regard to the quantities $\Phi$ and $\Phi'$. But as the equation resulting from this equation, namely, $TP = \frac{aa}{bb} \times \frac{yy}{a - x}$, may not be exact, I again add mentally a quantity

* Look back to the second note on article 42.—W. D.

tity $\Phi''$ which may render it so. This quantity $\Phi''$ can only be infinitely small; but I soon find that it is absolutely nothing; because the other terms of the equation are free from infinitely small quantities. For, by bringing all the terms of the equation to one side,

this equation, $\left(TP - \frac{bb}{aa} \times \frac{yy}{a-x}\right) + \Phi'' = 0,$

can have no place in the Method of Determinates, unless each particular term be equal to 0; consequently $\Phi'' = 0$, and $TP = \frac{bb}{aa} \times \frac{yy}{a-x}$, as before.

62. It appears, in general, from what has been said, that, if we put $P$ for the subtangent of any curve whatever, we shall have the imperfect equation $P = y\frac{dx}{dy}$; and consequently (by article 34) the equation $P = y \times lim. \left(\frac{dx}{dy}\right)$, will be rigorously accurate.

If we put Q for the angle included between the tangent of the curve, in any point whatever, and the corresponding ordinate, we shall evidently have

the *Tangent of* $Q = \frac{P}{y}$*, and the *Cotangent of* $Q = \frac{y}{P}$;

hence we have the imperfect equations,

$$Tang.\ Q = \frac{dx}{dy}, \text{ and } Cot.\ Q = \frac{dy}{dx},$$

or the rigorously accurate equations,

$$Tang.\ Q = lim. \left(\frac{dx}{dy}\right) \text{ and } Cot.\ Q = lim. \left(\frac{dy}{dx}\right).$$

63. *Problem* II. Required the value, which must be attributed to $x$, in order that it's function $\sqrt{2ax - xx}$ may be a *maximum*, that is, greater than if any other value whatever were attributed to $x$.

Make $\sqrt{2ax - xx} = y$, that is $yy = 2ax - xx$, and construct a curve, whose abscisse is $x$, and its ordinate $y$; and the problem will then be, To find the greatest ordinate of that curve. Now, since from the point $M$ the ordinates decrease

* The radius is here considered as unity; and therefore, *Tang.* $Q : 1 :: P : y$, &c.—W. D.

 both

both towards $A$ and towards $B$, it is evident that the tangent to the curve at the point $M$, ought to be parallel to the line $AB$. Then by putting (as in article 62) $Q$ for the angle formed by the tangent and the ordinate, we ſhall have, at the point $M$, $Cot.\ Q = 0$, or $Lim. \left(\frac{dy}{dx}\right) = 0$. I find, therefore, the differential of the equation of the curve, and I get the imperfect equation,

$$ydy = adx - xdx, \text{ or } \frac{dy}{dx} = \frac{a-x}{y};$$

and therefore the rigorouſly accurate equation will be

$$lim. \left(\frac{dy}{dx}\right) = \frac{a-x}{y}, \text{ or } Cot.\ Q = \frac{a-x}{y}.$$

But we ought to have $Cot.\ Q = 0$; therefore $\frac{a-x}{y} = 0$, or, laſtly, $a = x$, which was to be found.

64. The proceſs, therefore, for diſcovering the greateſt ordinate of any curve whatever, is to find the differential of its equation, and thence the value of $lim. \left(\frac{dy}{dx}\right)$ which muſt be made equal to nothing. This rule is commonly enunciated by ſaying ſimply, Find the differential of $y$, and make $dy = 0$. But what this enunciation gains in brevity, it loſes in accuracy.

65. *Problem* III. To determine the abſciſſe and ordinate, anſwering to the point of inflection, in a propoſed curve.

Let $ABMN$ (fig. 5.) be the propoſed curve; $AP$ the abſciſſe, and $MP$ the ordinate correſponding to $M$, the point of inflection ſought, and let $MK$, a tangent at that point, be drawn. It is plain that the angle $KMP$ is a *maximum*, that is, greater than the angle $LNQ$, formed by any other tangent whatever $NL$, and the correſponding ordinate $NQ$. The tangent, therefore, of the angle $KMP$ is alſo a *maximum*, and its cotangent a *minimum*. But the cotangent (by article 62) is, in general, $lim. \left(\frac{dy}{dx}\right)$: and conſequently (by article 63) we have $lim. \left(\frac{d \,.\, lim. \left(\frac{dx}{dy}\right)}{dx}\right) = 0$, which was to be found.

For

For example, let the equation of the proposed curve be $b^2y = ax^2 - x^3$, the differential of which will be the imperfect equation, $b^2dy = 2axdx - 3x^2dx$,

or the accurate one, $lim. \left(\frac{dy}{dx}\right) = \frac{2ax - 3x^2}{b^2}$;

therefore $\frac{2ax - 3x^2}{b^2}$ is a *minimum*,

or $lim. \left(\frac{d(2ax - 3x^2)}{dx}\right) = 0$,

and hence we have, $2a - 6x = 0$, or $x = \frac{1}{3}a$ *.

66. *Problem* IV. To find the area of a parabolic segment.

Let *AMP* (fig. 6.) be that segment: if we suppose the abscisse *AP* to be increased by the infinitely small quantity *PQ*, the segment will increase, in the same time, by the quantity *MNPQ*; that is, *PQ* being supposed the differential of *x*, *MNPQ* will be the differential of the segment whose surface is required. Conversely, therefore, that segment is the integral of *MNPQ*; that is, $AMP = \int(MNPQ)$. But, letting fall *MO* perpendicular to *NQ*, it is evident that the ultimate ratio of the space *MNO* to the space *MOPQ* is 0. The former space, then, is infinitely small, compared with the latter; and hence we have the imperfect equation $MNPQ = MOPQ$. Substituting, therefore, the second of these quantities for the first, in the accurate equation, $AMP = \int(MNPQ)$, we shall have the imperfect equation,

$$AMP = \int(MOPQ), \text{ or } AMP = \int ydx.$$

But, calling the parameter of the parabola *P*, the equation of that curve is

$$yy = Px; \text{ whence } dx = \frac{2ydy}{P},$$

an imperfect equation. Substituting, then, for *dx*, in the first imperfect equation ($AMP = \int ydx$) its value in the second, we shall have this new imperfect equation

$$AMP = \int\frac{2y^2dy}{P}. \quad \text{But } \int\frac{2y^2dy}{P} = \frac{\frac{2}{3}y^3}{P} \text{ (by article 58);}$$

* In this solution, the author, or rather perhaps the printer, had by mistake put *minimum* for *maximum*, and *maximum* for *minimum*; but I have made the necessary alterations.—W. D.

and

and therefore $AMP = \frac{\frac{2}{3}y^3}{P}$ *, an equation, which, as it contains none other than assigned quantities, cannot but be rigorously accurate. Q. E. I.

The same method by analogous reasonings, may be applied to the quadrature of all other curves, and it is easy to extend it to their rectification, as well as to the investigation of solids.

*Conclusion.*

(68.) These few examples may suffice to convey some idea of the spirit of the Infinitesimal Analysis. In vain will its opposers object, that to admit errors, as we do, by employing imperfect equations, is to ruin mathematical certainty. For how can these errors be dangerous, when we are possessed of infallible methods of eliminating them, and of marks by which we know with certainty that they have disappeared? Shall we renounce the immense advantages which this calculus affords, for fear of deviating, for an instant, from the rigorous procedure of elementary geometry? Or, shall we prefer a thorny foot-path in which it is so difficult to avoid being bewildered, to the plain and easy road by which this analysis conducts us to discoveries? Of the former description, we shall find the Method of Limits to be, if we should wish exclusively to employ it. For they who wish to proscribe the notion of infinitesimal quantities, are reduced to the necessity of supplying their place by common Algebra, which presents numberless difficulties, or obliged to use the words *infinite* and *infinitely small*, even while they are decrying them, and treating as chimerical the very things of which they are the symbols. We use these terms, say they, only in a figurative sense. But I ask, Whether a figurative

* Had our ingenious author proceeded here to substitute for $P$, its value (by the equation of the parabola) $\frac{y^2}{x}$, he would have had

$$AMP = \frac{2y^3}{3} : \frac{y^2}{x} = \frac{2y^3}{3} \times \frac{x}{y^2} = \tfrac{2}{3}yx;$$

that is, the parabolic segment $AMP$, and consequently *the whole parabola, is two thirds of a rectangle of the same base and altitude.*— W. D.

and

and abstruse style be that which comports with the simplicity of the mathematics, and still more with that rigorous accuracy with which the oppugners of the theory of infinities ought to fortify themselves? Do not the Method of Limits and that of Infinitesimals lead to the same results; or rather Are they not the same method differently employed? In a word, are not the same ideas to be represented in both, and the same relations to be expressed? Why, then, may we not represent these ideas, and express those relations, in the most clear and simple manner?

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*** M. Buée, an ingenious French clergyman, in a letter from Bath, to the editor, dated the 8th instant, wherein he mentions the Philosophical Magazine with deserved commendation, shows that the author's expression, in § 36, namely, $\left(\frac{TP}{y} - \frac{y}{a-x}\right) + \left(\frac{T'T}{y} - \frac{yMZ + aRZ - xRZ}{(a-x)\,.\,(2a-2x-MZ)}\right) = 0$, becomes correct by the insertion of a parenthesis, or *vinculum*; that is,

that $\left(\frac{TP}{y} - \frac{y}{a-x}\right) + \left(\frac{T'T}{y} - \left[\frac{yMZ + aRZ - xRZ}{(a-x)\,(2a-2x-MZ)}\right]\right) = 0$,

is equivalent, as it ought to be, to

$$\text{the equation } \frac{TP + T'T}{y} = \frac{2y + RZ}{2a - 2x - MZ}.$$

But I can by no means join M. Buée in thinking the omission of the parenthesis, which he has supplied, a trifling circumstance, or that such omission "is very common among algebraists." On the contrary, I have always apprehended, that without some character to distinguish compound quantities from simple ones, many, or most, algebraic processes would be unmanageable, and their results often wholly unintelligible. I must add, that I think it would be difficult to point out a single work on algebra, or fluxions, to which the author and the printer have done justice, and in which the *vincula*, when necessary, or even proper, have been very commonly omitted. In this very instance, M. Buée acknowledges that, from the want of a parenthesis, "instead of $-(a-x)RZ$, which it ought to be, we have $+(a-x)RZ$;" in other words, that the quality of this material part of the expression, is as completely changed by the omission, as the sense of a chemist would be by writing 10° *above* the zero of the thermometer, instead of 10° *below* that point. In fact, we find that, in most, if not all, books on algebra, from those of old Harriot

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and Descartes, down to the excellent Compendious Course of the Mathematics very lately published by E. M. G. Lemoine (d'Essoies) and Dr. Hutton, that the *vincula* are very seldom, if ever, omitted, where they ought to be inserted; and that they are sometimes inserted where, with but little danger of mistake, they might have been omitted.

In the original (as well as the translation) of the preceding little work, the ingenious author has not omitted a single vinculum which could affect the sense of his simplest expressions; and, in several instances, he has inserted that character where it might have been spared. Hence it was next to impossible for me to suspect that he (or the printer) had forgotten to insert it in the instance in question, and thus had inadvertently made the *only* expression, at all deserving the name of complex, a solitary exception to an indispensible rule, which otherwise had been *universally* observed, throughout the piece.—W. D.

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## VI. *On the Utility of Birds in destroying Insects and other Productions hurtful to Mankind.*

WHEN the destruction and waste of the fruits of the earth, occasioned by birds and insects, is duly considered, we cease to wonder at the anxiety of agriculturists and others in seeking out means for the destruction sometimes of the one and sometimes of the other, according as particular circumstances have made the havoc of either more or less observable on their fields. Indeed, on a hasty view of the subject the only matter that strikes the mind with surprise is, that unwearied and unceasing means have not been generally followed to extirpate many of those pests which all mankind seem equally to have an interest in destroying; for, every thing that diminishes the profits of the farmer adds to the price of the necessaries of life—and, consequently, adds to the quantum of labour performed by every individual.

But, in waging war against the feathered tribe there ought to be some discrimination, and the fact on a close examination of the subject will turn out to be, that we ought to form an alliance with some of them, as far as protection towards them can favour that end, with the view of the auxiliary aid they may afford us in extirpating the hostile bands

of

of worms, insects, and caterpillars, which often destroy the very germs of vegetable life.

We are led to these reflections by perusing Professor Barton's Fragments of the Natural History of Pennsylvania, lately published at Philadelphia. The utility of the following remarks on *insects, as the food of birds,* is our inducement for laying them before our readers; and the more so as several of the birds are natives of our own country, and a careful observation of the habits, &c. of other British birds would in a short time enable the natural historian to point out such of them as ought to be protected even by law. We need hardly observe, that many which partly live on seeds ought nevertheless to be included among the friends of mankind, on account of the greater benefit they yield by also destroying many insects, grubs, and other noxious vermin.

" It may in the first place be observed," says Dr. Barton, " that insects appear to be the first food of almost all the birds of our country. The more I have inquired, the more I have been convinced, that almost all birds live, in some measure, upon insects. Even those species which consume considerable quantities of seeds, berries, and fruit, also consume large quantities of insects: and there are reasons to believe, that others, whose principal food is the nectar of plants, also live partly upon these insects. Thus Mr. Brandis found the vestiges of insects in the stomach of the trochilus, or humming-bird, one of the last birds one would have suspected of feeding on animal food.

" The greater number of our smaller birds, of the order of *passeres*, seem to demand our attention and protection. Some of them feed pretty entirely upon insects, and others upon a mixed food—that is, insects and the vegetable seeds, &c. Many of them contribute much to our pleasure by the melody of their notes. I believe the injury they do us is but small compared to the good they render us. I shall mention, under six different heads, a few of the useful birds of this and some other orders.

" I. *Muscicapa acadica* of Gmelin? This is the lesser crested fly-catcher of Pennant. It is called, in Pennsylvania, the lesser or wood-pewe. This little bird builds in woods and in forests. After the young have left the nests, the parents conduct them to the gardens and habitations of men. Here the whole brood dwells in trees near the houses, where they are fed with the common house-fly, and other insects that are caught by the old birds. The young ones are soon capable of obtaining their food in the same way. This species of muscicapa visits us in the spring, and commonly continues with us until late in September, when it retires southerly to winter.

" II. The *motacilla sialis*, or blue-bird, feeds principally, if not entirely, upon insects, both such as are flying and such as are reptile. It is said they eat currants.

" III. Most of our species of picus, or wood-pecker, appear to me to be very useful in destroying insects, particularly those which injure our forest and orchard trees. It is true, these birds are sometimes injurious to us, by eating some of our finest fruits, particularly our cherries, and therefore pains are taken to expel them from our gardens. But they devour vast numbers of insects, particularly some of those species which prove so destructive to the trunk of the trees, such as the coleopterous insects, which, perhaps, do as much mischief as the caterpillars.

" IV. As a devourer of pernicious insects, one of the most useful birds with which I am acquainted is the house-wren, or *certhia familiaris*? This little bird seems peculiarly fond of the society of man, and it must be confessed that it is often protected by his interested care. From observing the usefulness of this bird in destroying insects, it has long been a custom, in many parts of our country, to fix a small box at the end of a long pole, in gardens, about houses, &c. as a place for it to build in. In these boxes they build and hatch their young. When the young are hatched, the parent birds feed them with a variety of different insects, particularly such as are injurious in gardens. One of my friends was at the trouble to observe the number of times a pair of these birds came from their box, and returned with insects for their young. He found that they did this from forty to sixty times in an hour; and, in one particular hour, the birds carried food to their young seventy-one times. In this business they were

were engaged the greater part of the day; say twelve hours. Taking the medium, therefore, of fifty times in an hour, it appeared that a single pair of these birds took from the cabbage, sallad, beans, peas, and other vegetables in the garden, at least six hundred insects in the course of one day. This calculation proceeds upon the supposition, that the two birds took each only a single insect each time. But it is highly probable they often took several at a time.

" The species of certhia of which I am speaking generally hatches twice during the course of the summer. They are very numerous about Philadelphia, and in other parts of the United States.

" The fact just related is well calculated to show the importance of attending to the preservation of some of our native birds. The esculent vegetables of a whole garden may, perhaps, be preserved from the depredations of different species of insects by ten or fifteen pair of these small birds: and, independently of this essential service, they are an extremely agreeable companion to man; for their note is pleasing. A gentleman, in the neighbourhood of Philadelphia, thinks he has already reaped much advantage from the services of these wrens. About his fruit trees he has placed a number of boxes for their nests. In these boxes they very readily breed, and feed themselves and their young with the insects which are so destructive to the various kinds of fruit trees, and other vegetables.

" V. The services of the ibis, in devouring the reptiles of Egypt, are well known. They procured to this bird a veneration and regard which form an interesting fact in its history, and in the history of human superstitions. The storks are, perhaps, not less useful. Pliny tells us, that these birds were so much regarded for destroying serpents, that, in Thessaly, in his age, it was a capital crime to kill them, and that the punishment was the same as that for murder. Virgil hints at the usefulness of the stork when he describes it as ' longis invisa colubris.' In Holland, even in our times, they go wild, protected by the government, from a sense of their usefulness in the way I have mentioned.

" In Britain, if it were not for the herons, and some other birds of this tribe, the frogs, and toads, and other reptiles, would increafe to fo great a degree as to prove a real nuifance. North-America abounds with birds of this order; and we even have fome fpecies of ibis very nearly allied to the ibis of Egypt—fuch as the *tantalus loculator*, or wood-pelican, the *tantalus ruber*, or fcarlet ibis, the *tantalus fufcus*, or brown ibis, and the *tantalus albus*, or white ibis. Mr. Bartram informs us, that the firft of thefe birds feeds 'on ferpents, young alligators, frogs, and other reptiles. It is commonly feen near the banks of great rivers, in vaft marfhes or meadows, efpecially fuch as are caufed by inundations, and alfo in the vaft deferted rice plantations.' This bird, both with regard to his general afpect, and his manners and habits, may be confidered as the ibis of America. In the midft of all their fuperftitions, I do not find, however, that the native Americans have ever paid any particular regard to this bird. I cannot learn that any of thefe fpecies of tantalus have ever been feen in Pennfylvania.

"VI. Some of the birds of the vultur-kind are extremely ufeful to man, by deftroying immenfe quantities of carrion, which ferve to vitiate the air, and, perhaps, in fome inftances, to give rife to malignant epidemics. The *vultur aura*, or turkey-buzzard of our country, is one of the moft ufeful of thefe birds. In Virginia it is protected by a law of that State. The Abbé Clavigero fpeaks of the ufefulnefs of the *cozcaquauhtli*, or king of the zopilots, the *vultur papa* of Linnæus. 'The zopilot,' fays this writer, 'is a moft ufeful bird to that country (Mexico); for they not only clear the fields, but attend the crocodiles, and deftroy the eggs which the females of thofe dreadful amphibious animals leave in the fand, to be hatched by the heat of the fun. The deftruction of fuch a bird ought to be prohibited under fevere penalties.'

"I am fenfible that thefe few facts, which are thrown together without any regard to order, can be of little ufe, except in as far as they may turn the attention of other perfons, who poffefs more leifure and information than myfelf, to the fubject, which is at once curious and important. It appears to me to be a fubject peculiarly interefting to my

 countrymen.

countrymen. Perhaps few parts of the world are more infested with noxious insects than the United States. The greater number of these insects are, I believe, natives of the country, though our partiality to the soil which gave us birth has not always allowed us to acknowledge this truth. Thus we give to the Hessians the honour of introducing among us that most pernicious insect, the Hessian-fly, which, for several years, has committed, and still commits, such alarming ravages on some of our most valuable grains, particularly the wheat and the rye. But this insect is, undoubtedly, a native of America. How it came to be, for so long a time, overlooked, will probably be mentioned in a memoir, concerning this and other noxious insects, which I hope to publish.

"Many of the pernicious insects of the United States seem to be increasing instead of diminishing. Some of these insects, which originally confined their ravages to the native or wild vegetables, have since begun their depredations upon the foreign vegetables, which are often more agreeable to their palates. Thus the *bruchus pisi*, or pea-fly, is a native, and seems originally to have fed, in a great measure unnoticed, upon the indigenous vegetables which are allied to the pea: but since the introduction of this last among us, it is the principal, if not the only, vegetable which suffers from the ravages of this insect. The Hessian-fly could not originally have inhabited the wheat, the rye, and other similar gramina of this kind, for these vegetables are not natives of America. It is now more formidable to us than would be an army of twenty thousand Hessians, or of any other twenty thousand hirelings, supplied with all the implements of war. The caterpillar, which has begun its ravages upon the leaves of the Lombardy poplar, that contributes so much to beautify our city, is, most probably, a native of our woods. It prefers this fine foreigner to the less palatable leaves upon which it has been formerly accustomed to feed. Other instances of this kind might be mentioned. They show how very necessary it is to watch the migrations of insects from the native to the introduced vegetables; and they teach us a truth, not, I think, sufficiently attended to by naturalists, that

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different kinds of insects are much less confined to vegetables of the same species, or to species of the same genus, than has been commonly imagined. It is certain, that the same species of insects, in America, often feeds indiscriminately, and in succession, upon plants of very opposite genera, and even of very different natural orders.

" Hitherto too little progress has been made among us in the discovery of remedies for the great mischiefs occasioned by insects. The subject has not been examined with sufficient attention. It has given place to discussions and inquiries of very inferior utility; and, I fear, it will not claim all that industrious attention which it so well merits, until the evil shall have spread still further. It is doubtless difficult, but it is by no means impossible, to prevent the ravages of noxious insects. In this important business something has already been done in our country. We have discovered a method of diminishing the depredations of the little bug, called cucumber-fly, which proves so destructive to the cucurbitaceous vines, particularly those of the cucumber and musk-melon. By manuring our wheat lands, and thereby increasing the strength and vigour of the wheat, we have lessened the evil of the Hessian-fly. By suspending, to our young apple, and other trees, pieces of tow impregnated with a mixture of brimstone and train-oil, we have learned how to frighten away the periodical locusts (*cicada septemdecim* of Linnæus), which often do so much injury to our orchards. The American Philosophical Society, by calling the attention of the public to the decay of our peach-trees, has brought us to a better acquaintance with the causes of this decay, and with the means of preventing it. Insects are, no doubt, one of these causes. We have made some progress in preventing the mischief of the *bruchus pisi*, or pea-fly, which proves so destructive to one of the finest esculent vegetables. But all that has yet been done is very little, compared to that which remains to be done. The subject is as new as it is important."

VII. On

## VII. *On Decortication, as a Means for freeing Orchards from Insects.*

IN general, to ſtrip off the bark of trees, is to kill them; and yet it appears, by ſome experiments made by Dr. Mitchill, of New-York, there is a time of the year when apple-trees (*pyrus malus*) may be peeled from their roots to their boughs, on all ſides, without ſuſtaining any damage from the operation. An experiment was made in 1799 upon an apple-tree, the whole body of which was decorticated, and whoſe branches nevertheleſs retained all their leaves and fruit. In two months after an entire new coat of bark was formed, which inveſted the tree on every ſide. The tree was as healthy and vigorous as ever. The ſeaſon for doing this is when the days are at the longeſt, that is, towards the end of June.

A tree peeled in the ſummer of 1798 outlived the ſucceeding winter, which was a very ſevere one, without being in any reſpect injured. Another, which was denuded in June 1799, produced its bark completely before September, and was as full of fruit as if nothing had been done to it.—"There is no doubt," ſays Dr. Mitchill, "that an orchard might be treated in this manner with perfect ſafety, if the operation was well-timed. The farmers ſay that it will make old trees young again; but I own, though I have ſeveral times been witneſs of the harmleſſneſs of the practice, it looks to me ſtill like a very violent and hazardous remedy. The experiment, however, demonſtrates a moſt remarkable power in the vegetable œconomy. Whether other trees may be thus decorticated I have not yet learned."

We may juſt obſerve, that the idea entertained by the American farmers is probably in ſome caſes very well founded; for as trees (apple-trees at leaſt) have the power of re-producing their bark, it muſt ſometimes happen that millions of inſects and eggs of inſects will thus be inſtantaneouſly removed, which otherwiſe would continue to burrow in and feed upon the tree. This circumſtance will account for the trees appearing as healthy after as before the proceſs, even if we ſuppoſe it in ſome meaſure injurious; for, as the health is to be judged of comparatively, it is plain that a tree allowed to retain its bark, may, in ſuch circumſtances as we have ſtated, be leſs healthy than one that has been ſtripped.

The fact, at any rate, deſerves the ſerious attention of all who have orchards. We mentioned ſome time ago*, that an inſect moſt injurious to apple-trees had made its appearance in this kingdom. Would it not be worth while to aſcertain how far trees might be freed from them by decortication, with the view of applying the remedy generally? We need hardly add, that in every caſe of the kind the bark ſhould be carried out of the orchard and burnt, to prevent the inſects from travelling back to the trees; and that a bandage impregnated with ſome fœtid ſubſtance ſhould be tied round the lower part of each tree to prevent the inſects that may have fallen during the proceſs from again aſcending. A. T.

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VIII. *Account of* C. F. DAMBERGER'S *Travels through the interior Parts of Africa, from the Cape of Good Hope to Morocco.*

[Continued from p. 253.]

ON the 17th of March 1788 our traveller took his departure from Kahoratho, and, directing his courſe north-eaſt, in a few days after croſſed a ſmall mountain, from the top of which he had a view of a beautiful plain beneath, with the town of Haouſſa lying in the back-ground, and in the front of the landſcape the great river Niger. Here he found himſelf all at once tranſported into a totally different country, which preſented, as far as the eye could reach, huts, houſes, delightful thickets, enlivened by goats, horſes, and camels feeding, and people buſy at their occupations both on foot and on horſeback. This diſtrict, our traveller aſſerts, is one of the fineſt, if not the fineſt, in all Africa. From the mountain it was a good hour's walk to the Niger, where he intended to croſs; but ſix of the Moors in the *oſitatho* † wanted to detain him, and to ſend his companions back. "Not underſtand-

* Philoſophical Magazine, Vol. III. p. 89 and 224.

† The ferry-houſe ſo called.

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ing their language," says our traveller, "I could not anſwer their interrogatories, and therefore ſtood ſilent. This confirmed them in the opinion that I was a Chriſtian, and therefore they told my companions (as I was afterwards informed) that they would not ſuffer me to enter the town. My attendants would have conſented to my being ſent back with all their hearts, had they not been afraid of loſing all hopes of the gratuity they expected to receive for bringing me; accordingly they refuſed to comply, and the diſpute was pertinaciouſly carried on on both ſides, till at length we began to capitulate. Our guides were diſpatched over the river to the little town of Booſu, while I remained in cuſtody of the others. Here at this river a guard is conſtantly ſtationed to keep a look-out concerning ſuſpicious perſons who apply to be ferried over, and to deliver them up to the king. Theſe people, however, frequently go beyond their duty, by occaſionally ſeizing a man and ſelling him to the ſlave-dealers, or ſending ſuch Chriſtians as they can kidnap to the Chriſtian merchants on the coaſt, from whom they obtain a conſiderable ranſom. In the evening of the next day our meſſenger returned in company with three armed Moors on horſeback. Theſe were to ſerve as our eſcort; and accordingly at break of day attended us over the river, for which the fare of each perſon was ſix zimpos. We ſoon came to Booſu, a ſmall lively town of about two hundred houſes and a hundred huts, ſituated half a day's journey from Haouſſa. The trading caravans that go from Haouſſa, Feene, Sille, and Tambuko, to Vangara, and into the kingdom of Mohopharo, ſtop here to furniſh themſelves with proviſions and provender for the horſes, which are here much cheaper than at Haouſſa. We were carried to the akomoni, or judge, who firſt entertained us with victuals, and then inquired, by means of an interpreter, concerning the purport of my journey. Having anſwered all his queſtions, he began to negotiate with my conductors, offering them ſix hundred zimpos for my perſon, in the deſign of ſelling me hereafter, as a ſlave, at a much higher price. But his offer was rejected; my conductors referring to the order of the king, to bring all wayfaring foreigners to him. We were now put under convoy of ſix armed men, to be conducted to the king in the capital. Though we had ſtill three German miles to go, yet the way did not ſeem tedious to me, as we were always meeting peeple, and my attention was ſtruck by a diverſity of objects.

"It was already dark when we came to Haouſſa; which, ſtanding on a mountain, may be ſeen at a great diſtance. The king being gone to reſt, we were obliged to remain with the guard at the gate; but we were treated with good proviſions, and particularly ſome delicate goat's fleſh broiled. About eight o'clock the next morning I was admitted into the court of the palace, and conveyed to the king. He ordered a number of queſtions to be put to me, and he was particularly intereſted in the account of my journey, of which he was eager to know all the particulars. In order to convince him that I was no ſpy, and to gratify his curioſity, I drew my journal from under my waiſtcoat, and related from it ſuch parts as I choſe, and eſpecially thoſe which I thought he would be the moſt entertained in hearing; the interpreter writing down ſeveral of theſe accounts on a piece of wood, which he handed to the king. When he had read them, he ordered meat and drink to be ſet before me immediately, then directed me to be taken to the houſe of his ſervants, and to be provided with a cloak. All this was accordingly done; and I was obliged to lay aſide my ſheep-ſkin pelice and waiſtcoat. The cloak, according to the cuſtom of the country, was made very long, and conſiſted of reddiſh-coloured linen. The number of the royal ſervants, including myſelf, amounted to ſixty-eight perſons. Our functions were to attend the king twice a day to the temple, and once to the place where he iſſued his decrees; alſo, whenever he went to viſit any thing out of the town, alternately to bear him on a litter. Eight perſons were commonly employed in the laſt office, ſo that the turn came in rotation only once in ſeveral weeks. When I had been here a fortnight, it pleaſed the king to make an excurſion to Booſu, and to viſit many things there; and, it being my turn, I was ordered to prepare for the journey. On receiving this notice I was extremely diſtreſſed, on conſidering how I ſhould go through with the ſervice, as it was generally performed in a ſort of harneſs. At firſt I

managed

managed tolerably well; but, as it was never the practice to make a halt, I was so overcome with fatigue that I fell down. The Moors, my comrades, attempted to raise me up; but, being utterly unable to concur with their efforts by helping myself, they took their trammels from the litter, and were going to beat me. On this, I set up a violent scream, in order to attract the king's attention, who, immediately giving orders to halt, inquired what was the matter, and commanded one of the Moors who attended him on horseback to dismount, to give me his horse, and to take my place as one of the bearers. This drew upon me the hatred of some of the attendants, of which, however, they let nothing appear, from reverence to the king, particularly as they perceived that he behaved kindly to me. After a stay of six days, the king returned to the capital, previous to his departure giving orders that I should not act as a bearer, but ride. I did as he had commanded, and, at our arrival, restored the horse to his owner with many thanks. No employments being assigned me, I took to some of my own accord: in particular, I sometimes visited a man who carved out various devices on wood, and he was highly pleased that I frequented him, in the hopes of learning several things of me. While with him, I made a square frame and a cupboard, not indeed so well as a European joiner; but then I had not the necessary tools, being obliged to make use of a sharp knife instead of a chisel, and a stone was the only substitute I had for a fine plane. After having visited this man's house for about ten days, the king one day sent for me, and forbade me to go for the future into the town: the fact was, that attempts had been made to bring me into suspicion with him, by persuading him that I entertained some ill designs. I vindicated myself by saying, that I had done no harm; that I had only gone at times to a workman in wood, because I was also one myself. This pleased him; and he told me, that, since I was a workman in wood, I should work for him. On my promising him that I would do so, he immediately ordered wood to be fetched, and likewise gave me permission to go every day, for two hours, and look about the town. The first thing I made for the king was a chest of eight drawers, and next a ſmall cabinet, which I painted red and yellow. Both pieces met with his entire approbation, looking at them very often, moving them firſt to one place, then to another; now putting one thing in them, and then ſomething elſe. I then made him three pair of knife-handles, and as many for forks, of goat-bones, adding to them ſilver rings, on which I carved ſeveral letters of his name, *viz.* M. H. Y. poliſhing them all as finely as I poſſibly could. At this he teſtified a hearty ſatisfaction, and promiſed to reward me as he ſhould ſee occaſion. One holiday I took the opportunity of aſking leave to go out of town to look about me. He did not refuſe my requeſt, but gave me a paſſport, which was a piece of wood, whereon was carved the royal arms, namely, a half tiger; telling me that I might be abſent till ſun-ſet, but that then I muſt attend him to the temple. Accordingly I paſſed out through the north gate to the village Vahaſua, ſituated at about an hour's walk from the town. On my approach to it, three men came out of it, riding directly up to me. Taking me for a deſerter, they told me, that if I did not go back immediately to town, they would carry me thither bound. Perceiving me make ſome heſitation, they leaped from their horſes, and ſtruck me with their ſabres. On this I produced my paſs; but they ſnatched it from me, tied my hands together, and, hanging me between two horſes, hurried me into the town to the king. The king expreſſed his ſurpriſe at this proceeding, as he had given me a paſs; and inquired what was become of it. On preſenting it to him, they ſaid, that they had taken it from me to prevent me from executing my deſigns. At the ſame time one of the men made up a ſtory of untruths, pretending that I was going to attack them, &c. During all this, I ſpoke not a word, liſtening only to what the man ſaid: this attracted the king's notice, and, turning to me, he aſked, whether the accuſer ſpoke truth. I juſtified myſelf by appealing to the licence granted me by his paſs; repreſenting to him, that, as I was not thoroughly verſed in the language of the country, theſe people might have miſunderſtood me, and erroneouſly thought that I abuſed them. The king was very patient and gentle during the whole converſation, which I interpreted as promiſing me

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ſome comfort. At laſt he commanded me to be carried to priſon, but ordered the principal accuſer to remain, that he might ſee, on the following day, how I ſhould be puniſhed. Being now utterly inconſolable, and convinced that the end of my life was drawing near, I had not ſlept a wink, when, in the morning, four ſoldiers came to me, bidding me follow them. As I went, I perceived people who pitied my condition; but others, ſtanding here and there, who ſeemed to enjoy my diſtreſs. On the public place where I was to be puniſhed, thirty ſoldiers on foot, and twenty on horſeback, were drawn up in a circle, in the middle whereof a buffalo's ſkin was ſtretched, and near it ſtood ſix young men, two of the ſtrongeſt having platted thongs in their hands. I was all over in a tremor, on the point of fainting every moment, concluding that I was either to undergo a violent death, or certainly to be cruelly ſcourged. The king, with his officers, now arriving, called for the principal accuſer, who ſprung into the circle apparently with great ſatisfaction. The king now aſked me, whither I had purpoſed to go? —I anſwered: 'To Vahaſua.'—'Where didſt thou meet the ſtranger?' ſaid he then to the accuſer; who replied: 'On the bye-road behind Vahaſua *.' On which the king immediately ordered the man to be ſtripped, then thrown on the buffalo's ſkin, and to have ſixty ſtrokes on the belly. All preſent were aſtoniſhed to ſee the puniſhment they expected was to be given to me inflicted on the accuſer; but they preſently ſaw how the matter ſtood, on hearing the king declare, that 'Nobody ſhould belye a ſtranger, or do him an injury, or endeavour to draw on him a puniſhment which he had not deſerved.' The delinquent, after receiving this chaſtiſement, was directly ſent beyond the borders of the country, while I was put in his poſt, and received his horſe. The king then related to me how it happened, that he had reſolved to make a ſtrict examination into the real ſtate of the caſe between me and the man now baniſhed. Having perceived, he ſaid, that it was the very perſon who, on the journey to Booſu, was obliged to diſmount from his horſe,

* That is the way to Feene, to which place numbers had ſecretly made their eſcape from this territory.

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and take my place in bearing the litter; and, having remarked at that time that he looked displeased and angry at me, he had therefore come to this conclusion, that the accusation was only founded in malice and revenge; adding, that his suspicions were fully confirmed by the confession of the two companions of the accuser, on their being brought to a strict examination.

"I now ventured to petition the king to let me depart; but this he refused, by saying, 'It is thy duty to do as I command thee.'—The matially (under officer) of the Moors now took me with him, delivering to me my horse, with a bridle of rope, and half a goat's skin for a saddle, at which I was much surprised; because I foresaw that I should not be able to do much with these implements, but should probably run the same risks as I had done before; accordingly I resolved to renew my request to the king, that he would allow me to prosecute my journey, or at least appoint me to some other post. The next morning I was ordered to appear before him; when he directly asked me whether I could ride, &c. to which I answered: No. 'Then thou must learn,' said he, 'as I design thee for a higher station, if thou wilt remain with me.' For the present I did not presume to solicit him again for my dismission, as he of himself had once more spoke of my remaining here. Had I resolutely insisted on being dismissed, I should have run the hazard of being sent as a present to his brother-in-law Soomahaty *, where I should infallibly pass my days in misery. I therefore resigned myself to fortune, hoping to make my escape at some fit opportunity, and in a short time learnt to ride, that is, to sit so firm on my horse as to be able to charge and fire my gun. My office was solely to be about the king when he chose to be carried abroad, or when he rode out on his great camel, which was led by four men; the rest of my time I employed in carving toys, or in strolling about the town for information

* King of Zamfara, who was represented as a very cruel man. He was really married to the sister of the king of Haoussa, keeping, besides, four hundred concubines, of whom he sold those who no longer pleased him, to the slave-dealers, and in their places picked up others about the country.

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concerning the neighbouring nations. At two feveral times caravans from the weftern Barbary paffed through on their way to Vangara. With either of thefe I would gladly have ftole away, but I found it impoffible to effect my defign. In one of my rambles I got acquainted with the richeft merchant in the town, named Koobi. This man carried on a confiderable trade, conftantly keeping two caravan-teams of a hundred and fixteen beafts of burden, and a number of flaves on the road. One of his flaves, an ingenious and active young man, diverted me at times by relating a variety of circumftances concerning his travels; and, among other things, I got out of him an accurate account of the march-route into the greater Barbary.—Now came on the rainy feafon, when the king never rode out, going only to the temple and promulgating his decrees in the court of the palace. I had therefore more time to prepare fecretly for my flight, by exercifing myfelf in pronouncing the hard words in the language of the country, learning of the afore-mentioned flave the moft ordinary expreffions in the language of the neighbouring nations, and the like. One day, the king, fhowing me a mufquet with a broken fhoulderpiece, afked me whether the workman in wood that I was acquainted with was capable of making another. I faid I would fhow him the ftock; and, taking it with me, I myfelf made a new ftock, which pleafed the king fo well, that he prefented me with fifty zimpos.

"At the end of the rainy feafon I purpofed to get off by ftealth; but my defign was fruftrated by the breaking out of a war between my king and the king of Vangara. We haftened to the field as faft as poffible, and the army was already muftered by the 24th of July; and though, as the rainy feafon was not entirely over, the foldiers were obliged to march, for half the day, up to the middle in water, yet they were ftill alert and courageous. The king of Vangara perhaps thought it impoffible for our army to pufh on through the valleys overflowed with water, in order to come at his frontiers; but he was miftaken.—Our king, likewife, made ufe of a ftratagem to prevent the king of Vangara from knowing when his army was to begin their march. On the 22d of July, about noon, an officer came to the capital from the enemy, attended by four Moors, bringing with him the declaration of war. It was written on a narrow ſlip of white leather, rolled on two long ſticks. On delivering it, he ſaid that the king his maſter would come here and fetch it back. Our king put on a very friendly countenance, gave the officer the beſt entertainment his palace afforded, but iſſued private orders for his own army to be kept in readineſs to march; ſaying to the officer, that when the valleys and plains were free from water, he would take back the ſticks himſelf; that is, would begin the war.

"On the 25th, before ſun-riſe, the infantry was in full march, and at noon was followed by half of the cavalry. The enemy's officer purpoſed to ſet out on his return that ſame day; but the king entreated him to remain, promiſing to accompany him on the following day, to prevent his being attacked. On the 24th, at noon, the king ſet out with his officers and the one belonging to the enemy, taking me alſo among his body-guard. On the firſt day we arrived at Taahaſa, a ſmall town of two hundred huts, where we were joined by five hundred Moors. Paſſing the Niger on the 25th, we were in extreme danger of our lives, inſomuch that we could not prevent the loſs of twenty men who periſhed in the floods, as the river was too much ſwollen, and yet the cavalry who could not be carried over, were forced to ſwim acroſs with their horſes. We now reached Maatoh, a village of forty huts, in the valley through which the Niger flows.

"On the 26th and 27th, we marched over a chain of mountains towards the eaſt, advancing on the 28th at noon to the Krahoto, or Gold-mountains. Here, making halt, we ſent the hoſtile officer to his king, commiſſioning him to tell him, that king Maonaouſſay was come into his country with his forces to viſit him. The officer had twenty men to eſcort him as far as Kahſuto, a ſmall town in Vangara. As ſoon as he was gone, accounts were brought that the infantry were already on the enemy's ground, where they waited for further orders. An European army, that excepted which Bonaparte led over the prodigious mountains of Switzerland, would

would never have ventured to do what I here faw performed by undifciplined troops. We had before us the two enormous ridges of mountains which we had already croffed in one of their turnings; but which in this place were far fteeper and more inacceffible than in the former, infomuch that I thought it abfolutely impoffible for us to furmount them: but I witneffed what I had confidered to be impracticable.

"At break of day the king iffued the neceffary orders to his officers; whereupon, in half an hour the cavalry that were with us drew up, flung their mufquets, and raifed a horrid fhout that re-echoed from the mountains. They cried out: *Ofothfugo, koato aqulaty!* that is, 'Death and 'the place of torment (with us *Hell*) fhall not deter us!' and the whole troop fprung up the mountain; fo that, though pieces of the rock flew off, not one of them met with any accident. The royal camp was now broke up, and it was our turn to clamber up the fteep declivity. I alighted from my horfe, and with extreme difficulty attained the fummit. The king continued fitting on his camel, fmoking a pipe of tobacco completely undifmayed. A new obftacle now made its appearance; for below ran an arm of the Niger, which we muft inevitably crofs. The king remained on the camel, led by the fwimming flaves, and got fafe over. I followed on horfeback, and likewife happily fucceeded; but I felt great pain in my feet, as the ropes here ufed for ftirrups had chafed the fkin fo forely, that the blood ran down. In like manner we were now to climb the fecond mountain; and during this perilous bufinefs the evening came on. On reaching the bottom of the other fide of the mountain we halted, and pitched our camp on the enemy's ground. At the diftance of about three leagues before us we difcerned a fire with fmoke rifing, which proceeded from the infantry that had marched on, and were already bufily employed in plundering, burning, and deftroying. At the fight of this, joy fpread throughout our camp; which now burft forth in fhouting and finging. The next morning powder and fmall pebbles, inftead of balls, were diftributed to all the people of the camp; as well to the fervants, flaves, and priefts, as to the foldiers, that we might be in a condition to refift in cafe of an attack; which, however, was not likely to be expected. At noon threefcore and two prifoners were brought in, and afterwards conveyed further. Thefe people were indeed deplorable objects, and excited great pity and compaffion, for they were miferably maimed and disfigured; fome being fhot, others hacked with fabres, and others wounded by fpears: befides, thefe wretches were entirely naked and deftitute, as every thing had been taken from them, and even their huts burnt. Here neither camp-hofpital, nor medicine-cheft, nor other fimilar means of relief were to be had; no ftyptics to apply to the wounded; but, when the prifoners, by crying and howling, expreffed the extreme violence of their pains, recourfe was immediately had to the cautery, by burning their wounds; and even this was done by efpecial grace of the king. Our march proceeded very flow; for this day we came only to within fomewhat more than two leagues of the little town Kahfuto, where we again encamped. We heard a firing the whole night through; officers likewife were frequently coming with reports to the king, though I learnt nothing of them. At day-break a hundred of our army were brought in wounded, and thirty prifoners taken from the enemy. We now heard that the main body of our army was before Kahfuto, which was obftinately defended by the enemy. Our flaves were therefore fent off to reinforce it; however, they were not wanted, as they had fcarcely been gone an hour when we faw the flames afcend from Kahfuto, and prefently after received intelligence that the enemy had retreated, having previoufly fet the town on fire. We now put forward, as the main army was gone on; having a bad road the whole day long, through thickets and over fandy flats, but frequently meeting with burnt villages. We encamped on the river Emog, on the other fhore of which the main army was drawn up. This river runs hither from the north, and flows through the whole territory of Vangara fouthwards. We were here in a difagreeable fituation; for, the plains near the river being ftill in feveral places under water, we were forced to go round them, wading through mud and dirt; therefore could by no means kindle a fire, and much lefs attempt to take reſt. On the right hand, indeed, we had a high hill; but we could not turn off to that, as we were endeavouring to come into nearer co-operation with the main army. Such of us as had horſes kept their ſeats the whole night long, in order, at leaſt, to get ſome reſt. At break of day we proceeded over the river, and marched for the capital. When the hoſtile army was within ſight, it was ordered that the baggage, under a guard of forty ſlaves and fifty ſoldiers, ſhould remain behind with me; when the king took upon him the command of the army, and puſhed onward. In a few hours the fight began with great cries and bellowing on both ſides, ſo that even we ourſelves were frightened. Our army, which had not reſted for ſome days, was ſeveral times repulſed, yet conſtantly preſſed forwards Till towards evening the event of the battle was undecided, now one army and now the other giving way: however, at laſt, when the darkneſs came on, our army maintained its ground, while the enemy retreated into the town. We took two hundred priſoners, and a number of trifling articles as ſpoil. With this action the main brunt of the war was over, as in the whole hoſtile territory throughout there was no other ſuch plain where the two armies could draw up in front of each other, but thickets, foreſts, narrow valleys, and mountains, in alternate viciſſitude. I remarked that both armies were totally unacquainted with tactics, and that with them every thing depended on the courage and temerity of the men. Though the battle laſted ſeveral hours, yet during all that time our people fired ſcarcely twenty times, and the enemy probably not oftener. In order to load their pieces the army every time fell back, and then advanced again: there was likewiſe a deficiency of powder. We reſted for two whole days; when, no meſſenger of peace coming from the enemy, we proceeded forwards. Now, however, we experienced a failure of proviſions; what we had brought with us being all conſumed, and there was nothing to be found in the enemy's country. The king then made proclamation, that it would not be adviſable to go back to fetch proviſions; but that, whoever was deſirous to eat, muſt puſh on with him to conquer the capital. What the king did, that the army was obliged to do; and therefore we proceeded onwards. We marched that whole day, and even half the night, without finding any nouriſhment either for men or horſes. At day-break we were ſtill above a league from the town, which we could already diſtinguiſh. Whichever way we turned our eyes, we ſaw men in great numbers, both of our own and of the hoſtile army. Our troops were meditating an attack, when they were anticipated by the enemy; who, pouring down the mountain which runs before the town, ſuddenly ruſhed upon us, and the fight began with the utmoſt fury. Having to contend on all ſides, we ſhould certainly have been loſt, had not the Moors heroically preſſed forwards and made themſelves maſters of the town. Being within it, they immediately diſpatched a deputy to the king with tidings of their ſucceſs. We therefore inſtantly received orders to pack up and follow the king into the town. Theſe we joyfully obeyed, in hopes of getting a plentiful ſupply of food for both men and cattle; but we found ourſelves deceived, as there was not the leaſt thing left: for both what the fugitive inhabitants had not been able to carry off, and what ſuch as ſtaid behind had ſtill poſſeſſed, was all conſumed by thoſe of our army who had forced their way into the place, and had likewiſe ſet fire to the town on the north ſide. The king's firſt orders were to extinguiſh the flames; after which he conſulted with his officers how we were now to proceed. I had my quarters in what was lately the habitation of an officer; where, though I found convenient lodging, yet I could find no ſupply for my ſtomach. To thoſe who had got nothing in the general pillage, a ſmall portion of meal was indeed diſtributed; but this was no more than ſufficient to appeaſe the appetite for a few hours. The next day was a day of reſt to the whole army, except to the king, who was employed in making the proper regulations. I was ordered to attend him through the town, to ſee whether any proviſions were to be picked up; we met with nothing, however, but the greateſt diſtreſs in all parts. Mothers with their children came and threw themſelves at the feet of the king, calling to him; but he heard them not: telling them, that if they did not go away and deſiſt from hindering his paſſage, they ſhould

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be killed. I was touched to the heart at this, and quite ſhocked at my king; though I well knew that in war-time pity is here entirely baniſhed: yet at other times I have ſeen him diſplay inſtances of pity and compaſſion. But I ſoon altered my opinion, for that very evening he iſſued orders to the army to quit the town the following morning; without, however, ſetting fire to it, as was the uſual practice, or carrying away with them the defenceleſs inhabitants, unleſs they had been in arms, as priſoners of war or ſlaves, but to leave them undiſturbed in their huts. The town of Vangara is upwards of a league in length, and nearly half as much in breadth; having ſix rows of houſes or huts, and three main ſtreets, running in a line from north to ſouth. The houſes are built of rough ſtones and mortar, but the huts of ruſhes and mortar. At the end of each ſtreet ſtands a temple, and the centre of the town is the market-place, where a croſs ſtreet runs through the other principal ſtreets. The palace is conſtructed of ordinary ſtones and mortar, incloſed by a wall ſix feet high, but in various places fallen to decay, altogether having a mean appearance. The town is ſurrounded by paliſadoes, which are in ſome parts defective and in others rotten. On the ſouth ſide of the town runs a ditch ſix feet in depth, where the cattle are watered, and from whence, in caſes of neceſſity, water is fetched for the people.

"At break of day we quitted the town, and retreated to our former camp at the foot of the mountains on the frontiers; the cavalry leading the van, and the infantry following.

"On the 23d an officer from the enemy came to our camp with propoſals of peace; who was admitted by the king on condition that the king of Vangara ſhould come and treat with him in perſon. This he accordingly did, and a firm contract of peace and friendſhip was concluded on the following terms: 1. The king of Vangara ſhall ſend to the king of Haouſa every year twenty ſlaves. 2. The king of Vangara ſhall furniſh aſſiſtance to the king of Haouſſa whenever he is attacked by other nations; in return for which he ſhall receive the ſpoils taken by his people in thoſe engagements. 3. The cattle which the ſubjects of the king of Vangara have carried off from the kingdom of Haouſſa ſhall be reſtored.

4. The

4. The two kings grant a freedom of trade reciprocally to the people of both nations.

"Peace being thus eftablifhed, the two kings behaved very friendly towards each other, fmoked tobacco together, converfing on indifferent fubjects, and thought no more of the unfortunate wretches who during this campaign had been taken prifoners, and, of courfe, fent into flavery; they remaining in the power of thofe by whom they had been captured. This war had coft on either fide about a thoufand men, feveral villages and towns being laid wafte, and fome thoufands of inhabitants deprived of their habitations and property. On the 20th of Auguft the treaty was ratified, and on the 28th we returned to the king in the capital.

[To be continued.]

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IX. *An Account of the Life and Writings of* LAVOISIER. *By* JEROME LALANDE.

ANTHONY LAURENCE LAVOISIER was born at Paris on the 26th of Auguft 1743, and enjoyed the advantage of a good education, on which his father, a man of property, beftowed great care. In the year 1764, the French government having propofed as the fubject of a prize of 2000 livres the beft method of lighting the ftreets, the prize was divided among three artifts who had made experiments on the fubject; but Lavoifier, who had examined it as a philofopher and man of letters, was rewarded in a different manner. The paper which he wrote in anfwer to this queftion was publifhed at the expence of the Academy of Sciences, and the King caufed a gold medal to be prefented to him by the prefident in a public fitting of the academy held on the 9th of April 1766. This paper, which contained a great many excellent mathematical and philofophical obfervations, announced the author's entrance in the career of fcience in which he afterwards continued to diftinguifh himfelf.

On the 18th of May 1768, he was chofen a member of the academy, in the room of Baron; and about the fame period he publifhed feveral treatifes in different periodical publications,

tions, such as Observations on the proposal for erecting a steam engine to supply the city of Paris with water, on thunder, on the northern lights, on the transition of water into ice, &c. The Memoirs of the Academy for the year 1770 contain Observations by him on the nature of water, and on the experiments said to prove the possibility of its conversion into earth. Lavoisier, however, showed that the earth obtained by the distillation of water was a part of the vessel which had been attacked during the operation: for, having continued the distillation without interruption 101 days, the total weight of the vessel and of the water contained in it remained unchanged, but the pelican had lost as much in weight as the water had increased.

In the year 1774 Lavoisier proved that the increased weight of metals during their oxidation, arose from their imbibing the air contained in the vessels in which the operation was performed; by which means a question that had long formed a subject of dispute among philosophers and chemists, and had occasioned many costly experiments, was finally determined. This formed a foundation for his new chemical theory, which he first opposed to the phlogistic system before adopted by chemists.

In the same year he published his small physico-chemical works. Priestley, in the year 1772, had made known his experiments on carbonic acid gas; but Lavoisier traced back its origin to Paracelsus, born in 1493, and to his pupil Van Helmont, born in 1588; and showed that even Palissey, Ray, Boyle, Hales, Venel and Macbride had been in part acquainted with this gas. He showed also that Dr. Black of Edinburgh had called the attention of philosophers to this important part of chemistry so early as the year 1756 *; and therefore he ascribed to him the honour of this new discovery, which in the course of twenty years had given occasion to so many others of the utmost importance to mankind.

Lavoisier proved by his experiments, that an elastic fluid, or kind of gas, was united in a fixed form with calcareous earth; he proved the presence of it in alkalies, and showed

* In Essays and Observations Physical and Literary, Vol. II. Edinburgh 1756.

that

that it was produced during the reduction of metallic calces and of the phosphoric acid. He not only applied to chemistry the different methods of experimental philosophy, and its various kinds of apparatus, but even introduced into it the spirit of accuracy and calculation, which had never before been employed in that way. With this union of two branches of natural knowledge, Lavoisier's principal work forms the commencement of a bright period in the history of their improvement.

Priestley having found that, during the union of nitrous acid with an earth, oxygen gas was generally produced, thence concluded that atmospheric air was a mixture of nitrous acid and earth. Lavoisier, on the contrary, showed in the year 1776, that oxygen gas was a component part of nitrous acid. This observation confirmed the truth of a great number of experiments, and gave rise to a variety of other discoveries.

In the year 1778 he was able to prove that the purest air, that necessary for respiration, or the dephlogisticated air of Priestley, was the cause of acidity, and existed in all acids. To this part of the atmosphere, contained in all acids, which converts the metals into metallic calces, and creates oxygen gas in union with caloric, he gave the name of *oxygen*.

In Germany, where chemistry has been much cultivated, this theory was soon adopted, and first made known by Girtanner at Gottingen, and Hermbstadt at Berlin, the latter of whom translated Lavoisier's Elementary Treatise of Chemistry into German. Soon after it was adopted also by Klaproth, Mayer, Lichtenberg, and Göttling. Westrumb, Crell, and Gren, however, still endeavoured to defend the old phlogistic system; but the majority was against them. Berthollet remained for some time undecided; but his own experiments soon induced him to embrace this theory, which conducted him to important discoveries.

In the month of June 1783, Lavoisier constructed an apparatus for burning hydrogen gas with oxygen gas in close vessels; and the result was a fluid, or rather pure water, the weight of which corresponded exactly with that of the two gases employed. Having learned that the same experiment had been made by Cavendish and Monge, he invented another

other apparatus for decompofing water, with which, by means of iron tubes, he feparated the hydrogen from the oxygen. Lavoifier proved alfo that atmofpheric air confifts of two kinds of gas, one of which is fit, and the other unfit, for refpiration; that the firft is oxygen, which poffeffes the property of uniting with bodies, and thereby becoming fixed; that this fubftance combines with metals during their oxidation, and with combuftible bodies when in a ftate of combuftion; and that in the firft cafe a metallic calx is produced, and in the laft an acid, which is of a different nature according to the kind of the inflammable body. On this depends the whole theory of combuftion, of the production of acids, and the divifion of natural bodies into inflammable and non-inflammable. On this depends alfo the knowledge of that kind of gas called formerly fixed air, but now carbonic acid gas, becaufe it is produced during the combuftion of charcoal, and is compounded of carbon and oxygen.

Lavoifier, therefore, was the firft who difcovered that the different kinds of gas are the refult of the folution of any fubftance by caloric; this conducted him to the conclufion that the caloric and the matter of light, difengaged during the combuftion of inflammable fubftances, does not arife from them, but from the air which furrounds them, and in which the combuftion takes place In this feries of experiments may be claffed that made by Lavoifier on detonation, which is nothing elfe than a fudden inflammation, the products of which are difengaged in the gafeous form.

In the year 1776, Lavoifier by means of Turgot was appointed fuperintendant of the powder manufactory, in order to improve that art; and this he did fo effectually, that the powder manufactured under his infpection was capable of driving a mufket-ball to the diftance of 120 fathoms, whereas that made before was capable of driving it only to the diftance of 90 fathoms. In the war of 1765, the Englifh bullets reached our veffels from a diftance at which ours could not reach them; but in the war of 1778 the cafe was reverfed. In the year 1788 he was in great danger of lofing his life in confequence of an explofion which took place during fome experiments then made at Effone.

All these experiments conducted him to a complete analysis of nitrous acid, an acid easy to be decomposed, but difficult to be extricated; and which, however, is of great importance, as it is a component part of saltpetre, and at the same time of gunpowder.

In the year 1789, Lavoisier endeavoured to bring the whole series of his experiments into systematic order, and thence to compose an elementary work on chemistry. Two editions of this work were sold off in the author's lifetime, and he had begun to prepare a new and improved one, in which new light would have been thrown on the whole science of chemistry. He intended also to give a collection of all his Essays in six volumes, but of these three only were published.

It would be difficult to determine what influence Lavoisier's discoveries have had, or may in future have, on the practice of the arts; but, if we consider the entire revolution effected in that of dyeing by the new chemistry, we shall find reason to entertain the best hopes respecting the rest. Almost all the phænomena in this art may now be traced back to burning and combustion, as has been sufficiently proved by Berthollet in his important work on dyeing. This art, therefore, which formerly depended on mere practice, is now founded upon a very simple and well-grounded theory.

The art of mining, of assaying and fusing metals, of preparing steel, of bleaching linen and wax; in a word, almost all the chemical arts, under the direction of the new theory have been rapidly improved and brought near to perfection.

By applying these discoveries to the phænomena of breathing, Lavoisier has shown that this vital function is a real combustion of carbon and hydrogen, by which carbonic acid and water are produced. The effect of this combustion is animal heat, the degree of which he was so fortunate as to ascertain by calculation. His experiments on this subject conducted him to means for determining the remarkable relation which exists between accelerated respiration, the circulation of the blood, and perspiration, and between the different powers, and the application made of them by nature. He had laboured also for a long time on a particular work on the subject of digestion.

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The last, and perhaps the most important of Lavoisier's labours related to animal perspiration, on which subject he read a paper before the Academy of Sciences on the 4th of May 1791. A part of this paper may be found in the Memoirs of the Academy for the year 1790.

Lavoisier first lays it down as an established principle, that the animal body is maintained by respiration, perspiration, and digestion. He then examines in a chemical view each of these effects, the nature of the perspiration of the skin and of the lungs, distinguishes the effects from each other, and, as it were, interrogates nature respecting the three causes by which they are produced. He invented an apparatus by which every thing that relates to evaporation externally, and to breathing internally, could be observed. In conjunction with Seguin, he made on this subject some exceedingly difficult and laborious experiments, by which he found that a man by perspiration loses daily 2 pounds 13 ounces; that in the course of 24 hours he consumes 33 ounces of oxygen gas; that in the same period 8 cubic feet of carbonic acid gas, one third of which consists of carbon, and two thirds of oxygen, are disengaged from the lungs; that the quantity of water produced in the lungs amounts to 1 pound 7 ounces, of which 3 ounces are hydrogen, and 20 oxygen, and that only 6 ounces of water are formed by the perspiration of the lungs. For these experiments he had provided balances which did not err half a dram in 125 pounds.

By these accurate and difficult experiments Lavoisier had obtained great insight into the causes of several diseases, as well as in regard to the means of assisting the powers of nature in curing them, and on that account had resolved to overturn the immense colossus of medical prejudices and errors which had been before established. None of his undertakings was of more importance than this, and it is much to be lamented that he did not live to carry it into execution.

Between the years 1778 and 1785, he improved and cultivated at his own expense 240 acres of land in la Vendée, in order that he might promote agriculture by setting a good example before the farmers; and his mode of culture was attended with so much success, that he obtained a third more of crop than was obtained by the usual method. In the course of nine years his produce was doubled; but as the capital he laid out did not produce him five per cent., he was thence induced to form a plan for lowering the interest of capitals, and extending leases to the period of 27 years.

The committee of the constituent assembly of 1791, appointed for the purpose of settling the taxes, having requested Lavoisier to assist them by his knowledge in accomplishing the object which they had in view, his ideas were of great assistance to them in the formation of a plan by which the whole system of income and expenditure was greatly simplified. In order that he might give the committee the necessary information on this subject, he communicated to them an extract from a very large work on the different productions of the country, and their consumption, for which he had been long employed in collecting materials. This extract was printed by the National Assembly, under the title of *Richesses territoriales de la France*, and is undoubtedly the best work on the subject.

In the year 1791 he was appointed a commissioner of the national treasury; and, without abandoning the study of the sciences, he introduced into this department such order and regularity, that the proportion between the income and the expenditure in all the branches of government could be seen at one view every evening.

In the great and important undertaking of establishing in France a new system of weights and measures, with which the academy had been occupied for some time, none of the members was more active or more useful than Lavoisier.

In order that he might diffuse new light on the important but not sufficiently illustrated doctrine of the expansion of metals by heat, he constructed an apparatus by which metal rods immersed in water and exposed to different degrees of heat, put in motion a telescope, which showed on a distant object the smallest degree of expansion.

In the year 1793, it being necessary to have a basis measured with the greatest accuracy, in order to determine the length of an arc of the meridian, he erected in his garden rods of platina and copper, which he employed as metallic thermometers,

thermometers, and on which each degree of variation in the temperature could be accurately obſerved. On this occaſion he aſcertained the proportions of their expanſion, and theſe rods were afterwards employed in meaſuring a baſe between Lieuſaint and Melun; from which were afterwards deduced the length of the meridian between Dunkirk and Barcelona, the circumference of the earth, and the ſtandard for the new French meaſures.

It might have been expected that a philoſopher poſſeſſed of talents ſo rare and uncommon, would have inſpired with reſpect for his character the moſt ſavage and worthleſs of mankind. But at that period the helm of the French government was in the hands of a ſet of monſters to whom nothing was ſacred, and whoſe unbounded ambition ſacrificed every thing to the hope of flattering the deluded populace. They conceived that nothing could contribute more to the accompliſhment of this view, than to offer up as victims at the ſhrine of popular licentiouſneſs all the farmers-general; and in conſequence of this cruel meaſure, twenty-eight of them, among whom was Lavoiſier, were put to death, for crimes real or pretended, on the 8th of May 1794, by the bloody revolutionary tribunal.

In the year 1771, Lavoiſier married Mary Anne Pierette Paulze, the daughter of one of the farmers-general, a lady of agreeable manners, and poſſeſſed of conſiderable talents. She engraved the copper-plates for his laſt work.

Lavoiſier was of large ſtature; complacency and penetration were diſplayed in his countenance; his behaviour was mild, civil, and polite; and his activity knew no bounds.

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## X. *Proceedings of Learned Societies, Miſcellaneous Articles; and new Publications.* *Feb.* 1801.

### ROYAL SOCIETY OF LONDON.

JAN. 29. A paper on a moſt remarkable luſus of a ſheep, by Anthony Carliſle, Eſq. was read. Alſo an anatomical paper on a Rhinoceros, by Mr. Leigh Thomas.

On

On the third and tenth of February a curious paper by I. J. Schroeter on the accidental changes of the fixed nebulæ. A feries of continued obfervations have convinced him, that the irrefoluble nebulæ, or thofe of which the diftinct ftars cannot be feen by the higheft powers of the telefcopes applied to them, are fubject to the fame increafe and diminution of brightnefs that fome of the fixed ftars have been obferved to have: he fuppofes that nebulæ of this defcription are not at the amazing diftance conjectured by fome aftronomers; but, that they are collections of the luminous fluid enveloping fome of the fixed ftars, and of a fimilar nature to the zodiacal light which furrounds our fun.

On the tenth, a mathematical paper by Mr. Woodhoufe; but from the nature of it, being compofed of tables, the introduction only could be read.

On the fame evening alfo, An account of the difcovery and working of a lode* of filver in Hurland mine, in the parifh of Gwinear, 6 miles from St. Michael's Mount in Cornwall. This is a moft valuable paper, and from the rank of its author (John Hawkins, Efq.) we may hope that the ftate of the mines in Cornwall, and the geology of that highly interefting county, will be laid before the curious. This lode is one of thofe which, in the language of the miners of that county, are termed crofs lodes, i. e. running north and fouth, it interfects a lode of copper running eaft and weft. The filver is very rich; but, however productive it may turn out, it cannot be worked much longer, as the mine will foon be nearly 200 fathom deep, and there are no mechanical contrivances made ufe of there that can raife water from a greater depth.

On the 19th a paper was read on arfeniats of copper, by Count de Bournon.

The tufk of an elephant was exhibited, in which a fpear had been lodged, difcovered only by fawing the tufk by a manufacturer: the ivory encircling it 2 inches, accompanied by a defcription by Charles Combe, Efq.†

* The Cornifh term for a vein.

† A few years ago a comb-maker in Cannon-ftreet, in fawing an elephant's tooth, met with a hard fubftance which he fawed out. It proved to be a bullet made of very pure gold.—EDIT.

## SOCIETY OF NATURAL HISTORY AT PARIS.

C. Latreille has described a new genus of insects. This genus, to which he has given the name of *pelecinus*, from a Greek word, the application of which is little known, belongs to the order of the *hymenoptera* of Linnæus, or that of the *piezates* of Fabricius. The insect which forms the subject of this genus has been hitherto placed in that of the ichneumons of Fabricius.

## PHILOMATIC SOCIETY.

C. Bose has described a new species of pulex (*pulex fasciatus*). This genus in systematic authors contains only two species: one known in every country, which attacks almost all the mammiferæ, and distinguished by the name of *irritans*; the other (the *nigua*) found in warm countries, which insinuates itself into the skin, and on that account is called *penetrans*. C. Bose has for a long time observed a third species which lives on *moles*; but he neglected to describe it, and it was lost in his collection. He however found it again not long ago on a *dormouse (myoxus nitela* Lin.), and has made it known.

Its colour and form are the same as those of the common kind, but it differs from them by a row of very black short and thick bristles at the upper part of the second ring. He therefore proposes to characterise it by adding to the description of the *pulex irritans* the following words: *vertice fasciâ nigrâ*, because the hairs have a great resemblance to a band, and for this reason he calls it *pulex fasciatus.*

## CHEMICAL NOTICES.

M. Lampadius of Freyberg has noticed, that if crude, or, which is better, purified acidulous tartrite of potash be heated till no more fumes or flame appear, and water be then added to it, ammonia is produced. It is best observed while the mass is still warm. The same tartrite may be employed repeatedly, and will still yield ammonia, as long as any carbonaceous matter remains, by merely heating it, and then wetting it with a few drops of water. Acidulous oxalate

late of potash treated in the same manner gives a similar result. Charcoal mechanically joined to potash does not produce the effect.

C. Haüy has observed that native sulphur, of which some kinds are very transparent, possesses the property of double refraction.

C. Cadet having mixed the materials to be employed in producing sulphuric ether, *viz.* alcohol and sulphuric acid, and set them by in a cool place closely corked up in a bottle, at the end of 30 hours found the bottom of the vessel covered with well-formed crystals of oxalic acid.

C. Badollier, apothecary at Chartres, has announced a new method of preparing acetic acid. It consists in distilling, in a retort placed in a sand bath with a receiver adapted to it, a mixture of equal parts of sulphate of copper and acetate of lead.

To examine the products, C. Badollier made use of a pneumatic apparatus: during the operation he obtained only a small quantity of elastic fluid, which he found to have arisen from the dilated air contained in the vessels. This air, when subjected to the proper re-agents, exhibited no traces of carbonic acid. As he presumed that his acetic acid might contain sulphuric acid, he tried it by means of a solution of muriate of barytes, which occasioned no precipitate.

It is to be remarked that the distillation takes place very rapidly and with a very moderate fire; that the acid obtained by this method has no empyreumatic odour; that it is inferior neither in quantity nor quality to that obtained by the acetite of copper; and that there is no portion of the acid decomposed, which communicates to the other a disagreeable odour, as is the case when the old process is used. Besides the saving in time and fuel, the acid prepared by this new method can be sold for one fourth of that prepared by distilling acetite of copper.

We confess that we cannot see much difference between this and the old process; for it has been long known that sulphate of copper and acetate of lead mutually decompose each other, and form sulphate of lead and acetate of copper. If heat be applied, the latter, of course, will part with its acid.

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## PHILADELPHIA MEDICAL SOCIETY.

The Philadelphia Medical Society, defirous of increafing the ftock of ufeful medical knowledge, have determined to offer a medal, of the value of fixty dollars, for the beft differtation in anfwer to the following queftion:—" What are the effects of the following medicines upon the human body, efpecially upon the pulfe; *viz*. hyofcyamus niger (black henbane), datura ftramonium (thorn-apple), conium maculatum (hemlock), camphor, amber, mufk, digitalis purpurea (fox-glove), fcilla maritima (fea-fquill), rhododendron maximum (an indigenous American plant called mountain laurel), and the principal preparations of lead?"

Differtations on this fubject, competing for the prize, and written either in the Englifh, French, or Latin languages, muft be forwarded (poft paid) to the fecretary of the Philadelphia Medical Society, on or before the firft Saturday in February 1802. To each of the differtations a motto muft be prefixed, and the fame motto muft be put upon the back of a fealed letter containing the name of the author. All the differtations, excepting that to which the prize fhall be adjudged, will be returned to any place that may be directed, with the letters which accompanied them unopened. Thus the names of unfuccefsful candidates will be known only to thofe to whom they may themfelves communicate them.

The American Medical Repofitory, Vol. IV. contains the following remarks:—If the fixed vegetable alkali is an elementary material, it might be expected to fhow itfelf after the decompofition of plants by putrefaction as well as by incineration. Yet the American forefts, where immenfe quantities of timber are rotting down, afford no evidence of this. On the contrary, the trunks of the largeft trees, as they undergo gradual decay upon the ground, give no fign of pot-afh. Frequently in the progrefs of decompofition, the annual circles are fo detached from each other as to be eafily peeled off, and the cohefion of the wood fo much leffened, that the blade of a knife or of a fword can be thruft in toward the medullary part of their whole length. Now there is no faline efflorefcence on this rotten timber in dry weather, nor is there any alkaline tafte, nor any pot-afh to be obtained by macerating it in water, nor are vegetable blues or purples in the least rendered green by dipping in such water. Indeed, the manufacturers of the article, which is one of the great subjects of export from New York, know that in clearing the wilderness, the trees, in order to afford pot-ash, must be burned; if they are suffered to rot, no alkali can be procured. On the contrary the rotten wood contains an acid. Did pot-ash pre-exist in the wood, why should it not be evolved by putrefaction? These considerations, and the analogy of ammoniac, lead to a persuasion, that this alkali and soda are compounds. Whether, as some have asserted, carbon and azote are the ingredients, or whether there are other constituent parts, are points not as yet settled.

## DISEASES OF THE EYES.

Dr. Mitchill of New-York states (Med. Rep. Vol. IV.) a case of a girl whose constitution had been considerably injured by siphylis, being affected, in addition to that disease, with an ugly and scabby eruption over her face and neck, and with an enlargement and inflammation of the lachrymal sac of the right eye. Determining to defer the particular treatment of the *fistula lachrymalis* until the general and more urgent disease of her constitution should have abated, he prescribed, besides other things, a weak solution of carbonate of soda in water as a lotion for her face. This had the usual effect of disposing the eruptions to dry away and disappear in a few days; but what he did not at all expect, *the fistula lachrymalis disappeared too*, under the continuance of the alkaline wash, and returned no more.

Dr. Guthrie of Petersburgh mentions (Duncans' Annals of Med. for 1799) the remarkable efficacy of the effluvia of spirits of turpentine in the cure of an old and obstinate case of *ophthalmia*, which had resisted all the common remedies. It was discovered by accident. The patient, whose disease had arisen from a too assiduous employment of his eyes on minute objects, in the pursuit of his business, aggravated likewise by the painful assistance of glasses, first obtained relief of the inflammation of his eyes by the effluvia of this substance alone; and afterwards of the remaining affection of the eye-

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lids by the application of the ſpirit itſelf. The pain and inflammation following this application were extremely ſevere, but ſoon terminated in his complete cure.

*Parkinſon's Chemical Pocket-book, or Memoranda Chemica. Second Edition.* Symonds, Murray and Highley, &c.

We announced the publication of the firſt edition of this valuable little work in our ſixth volume, p. 364. We then obſerved, that Mr. Parkinſon's work could not fail to be uſeful in no mean degree, though we feared that in a few caſes he had admitted facts of uncertain authority, and theories not ſufficiently ſupported. In the preſent edition, which we are happy to find ſo ſoon called for by the public, the author has ſeparated as much as poſſible the varying opinions which he wiſhed to enumerate, from the other part of the work, and has introduced ſuch new chemical facts as have been eſtabliſhed ſince its firſt publication.

MINERALOGY.

The Chemical Society of Philadelphia, beſides a variety of other minerals from different parts of the United States, have lately received a ſpecimen of the golden or auriferous pyrites from Virginia, from ten pennyweights of which three grains of gold, twenty-four carats fine, have been extracted.

A quantity of manganeſe has been ſent to the Society from the county of Albemarle, where it is found in abundance. This mineral now retails in Philadelphia at the rate of elevenpence per pound.

A variety of the ſulphate of barytes, called lapis hepaticus, accurately deſcribed by Cronſtedt as the lieberſtein, or liverſtone, of the Germans and Swedes, has alſo been forwarded to the Society from the ſame place. This mineral almoſt always accompanies the beſt metallic ores, and is conſidered by mineralogiſts as a happy preſage of finding them. According to the celebrated Becher, it is a certain indication, *aut præſentis aut futuri metalli.*

ANTIQUITIES.

The French in Egypt have not been idle in their reſearches into the immenſe treaſures of antiquity ſo long concealed in

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this celebrated country. They have corrected many topographical errors, the necessary consequence of mere admeasurement, by astronomical observations; and laid the foundations for a correct geographical map of the country. A complete knowledge of the monuments of antiquity which now remain (mostly in Upper Egypt) has been obtained; and plans of the scite of many celebrated antient cities have been taken. Drawings have been made of the sculptures on the antient monuments, as well as of the monuments themselves. In the sepulchral excavations of Thebes many mummies in high preservation have been found; and, which is of much greater importance, along with them several rolls of papyrus, which enrich the possessors with some of the most antient manuscripts in the world. On the base of a peristile at Esne a sculpture of the zodiac has been discovered, in which the solstice is indicated in Virgo; and another in the great temple of Dendara, which represents the sun in Leo: his approach to Cancer has also been observed. These show at the same time the antiquity of the temples, and the knowledge which the Egyptians possessed of the precession of the equinoxes.

Two vases containing about two thousand Roman gold coins have lately been discovered near Beauvais in France. They consist chiefly of the emperors from Galba to Geta inclusive, many of them of beautiful workmanship and in high preservation. They were eagerly seized upon by the persons in the neighbourhood, and it is believed that the fear of losing them keeps some of the most valuable of them concealed; especially those of the empresses. This will, however, probably for a long time be a source of valuable specimens for cabinets; for sooner or later they will come to light.

## THE AMERICAN ELK DOMESTICATED.

We are happy to find that a successful attempt to tame this animal has been made by Mr. Chancellor Livingston, President of the New-York Society for promoting Agriculture, Arts and Manufactures. It may not perhaps be too much to hope, that at no very distant period the old world may thus receive from the new a useful domestic animal in return

return for the horse—a creature for which America is in-indebted to Europe.

"No attempts," says Mr. Livingston (Part III. of the Transactions of the New-York Society), "have been made to render these noble animals useful. Content with sacrificing them to our hunger, we have never thought of drawing, from their activity and strength, the aids which they might afford us by their labour. The elk is larger than the rein-deer, and, when taken young, as domestic as the ox, as I find from having three that run with my cattle, and appear as much attached to them as to their own species. I have lately attempted to break two of them to the harness, and am much encouraged by my first essay. They have been but twice bitted, and appear to me to be quite as docile as colts would be at their age. They apply their whole strength to the draught, and go on a steady pace. Their mouths appear to be very tender, and some care is necessary to prevent their being injured by the bit. Mine are about two years old, and are not less than thirteen hands high: their thighs are as muscular as those of the horse. In their native woods the males grow to about fifteen hands, as far as I can collect from the information of hunters. It is probable, however, that in a state of domesticity they would grow much larger, as all graminivorous animals are pinched for food in our climate during the winter. Their gaits are a walk and a trot: they never bound like the stag. If upon trial it is found that the elk can be rendered useful in the harness, it would in many views be an acquisition: as its trot is very rapid, it is probable that, in light carriages, they would out-travel the horse. The rein-deer affords abundance of rich milk. It is not to be doubted that the animal, which is only a larger species of rein-deer, might be brought to furnish our dairies. It appears to me to be less delicate in its food than a horse. Mine have been kept fat on hay alone, though they were very negligently attended. They are long lived, and more productive than any domestic beast of burden, generally producing two fawns at a birth. By castration they may be prevented from getting horns, if, as I suppose, their enormous size should be considerd as inconvenient. It is probable,

bable, too, that the superabundant nutriment which is annually expended upon the horns, would, in that case, add to the bulk of the body.

THE WILD GOOSE DOMESTICATED.

Attempts have frequently been made on Long-Island to render the wild goose, which winters in the bays adjoining the Atlantic ocean, a tame and domesticated bird. Individuals of this species have accordingly been catched alive by the gunners after having been wing-broken by a shot, and carried home free from any other injury. When thus disabled from flying, they become gentle, and will mate with common geese. They even breed together; but the offspring is a mule, incapable of further propagation. Mr. Daniel Coles, of Oyster-bay, has gone a step beyond others in this business. He has a wild-goose and gander in a domesticated state, whom he keeps from flying away by taking off the extreme bones of the wings at the joint. The goose has laid eggs and hatched a brood of goslings. For fear of losing the young ones, their wings have been treated in the same manner; and the whole family now composes (September, 1800) a beautiful flock of wild geese in a domesticated state. They are as gentle as common geese, and live upon the food obtained about a house and on a farm quite as well. Mr. Coles even found that the goslings, on the day of being hatched, ate Indian meal as readily as chickens. They are more active and handsome than the tame-goose, and their long necks are arched more like those of swans. If this experiment should be continued for several generations, it is highly probable the temper and habits of the breed may be changed, so that the descendants of these wild-geese may lose their inclination to fly from country to country, and attach themselves, like turkeys, ducks, and other birds whose progenitors were once wild, to the society and protection of man. Should Mr. C. meet with no disasters, it is not improbable that the wild-goose will be eventually added to our stock of poultry.

NEGRO TURNING WHITE.

The change of colour which Harry Moss has within a few years undergone, from black to white, has been published so often

often that few curious perfons are ignorant of it. In the town of North-Hempftead, fomething of the fame kind is now to be feen. A young negro, named Maurice, aged 25 years, began, about feven years ago, to lofe his native colour. A white fpot appeared on the right fide of his belly, which is now about as large as the palms of two hands. Another white fpot has appeared on his breaft, and feveral more on his arms and other parts; and the fable cloud is plainly difappearing on his fhoulder. The fkin of thefe fair fpots is not furpaffed by the European complexion. His general health is and has been good; and he has fuffered no fcalding ulceration, fcabbinefs, or other local difeafe. The change is not the dead white of the *Albinos*, but is a good wholefome carnation hue. Such an alteration of colour as this, militates powerfully againft the opinion adopted by fome modern philofophers, that the negroes are a different *fpecies* of the human race from the whites, and tends ftrongly to corroborate the probability of the derivation of all the *varieties* of mankind from a fingle pair. Facts of this kind are of great value to the zoologift. How additionally fingular would it be, if inftances of the fpontaneous difappearance of this fable mark of diftinction between flaves and their mafters were to become frequent! They would then be no lefs important to the moralift and political economift.

### LOCUSTS.

The following obfervations on locufts, made, in the year 1715, by the Rev. Andrew Sandel *, then rector of the Swedifh church in Philadelphia, are left on the records of the faid church, in the Swedifh language:—" In the month of May a peculiar kind of grafshoppers or flies, called by the Englifh *locufts*, iffued from the earth. They came up every where, even on the hard roads. They were enabled to pierce the earth by means of a fhell that covered the whole body, even the mouth and feet. Having iffued from the earth, they crept out of their fhells, flew about, placed themfelves every where on the trees, and made a peculiar noife. As they

* This is the man whom Linnæus quotes (1 Amœnitat. Academ.) in his hypothefis of fever, as affirming the co-exiftence of *intermitting fevers* and *argillaceous foils* in Pennfylvania.

were

were in great numbers over the whole country, their noiſe was ſo loud that the people could hardly hear the bells in the woods. They ripped the bark of the trees, and put worms therein. Many expected that the trees would be dried by this; but we found, next year, that it did not happen. Swine and fowls fed on theſe inſects. The Indians did alſo eat them, eſpecially on the firſt arrival, after a previous ſlight roaſting: from this it is probable that they are of the ſame kind with thoſe eaten by John the Baptiſt. They were of ſhort continuance, dying in June."

*Remarks.* The worms mentioned were, no doubt, thoſe white worm-like eggs which the preſent locuſts depoſit in the bark. All the other circumſtances correſpond with thoſe that now take place.

That the locuſts were not deſtructive, appears by the account given by the ſame author, on the extraordinary fertility of that year, in wheat, rye, Indian corn, oats and apples.

That year was alſo remarkably healthy among the Swedes, as appears from the ſmall number of deaths on the funeral records, which included a diſtrict at leaſt fifteen miles north, weſt, and ſouth from Philadelphia.

### BREAD FRUIT.

A ſurgeon lately arrived at Rotterdam from Surinam ſtates, that in that colony they have now large thriving plantations of the bread-fruit tree, which are exceedingly productive; that the bread made from it is as good as that from wheat; and that for this purpoſe the fruit is ſliced, dried in the ſun, and then pounded, and this flour with water made into paſte, which riſes as well as wheat flour. Hopes are entertained that this valuable tree may be introduced into Europe.

### DEATH.

On the 21ſt of January laſt, ſuddenly, Profeſſor Abildgaard, Secretary of the Royal Academy of Sciences at Copenhagen. He was the founder of the Veterinary School in Denmark: his pupil, Profeſſor Viborg, will no doubt ſucceed him in the veterinary department.

## XI. *Life of* Abraham Gothelf Kästner, *Professor of Mathematics at Göttingen.*

A. G. KÄSTNER, professor of mathematics at Göttingen, was born at Leipsic on the 27th of September 1719. His father, Abraham Kästner, maintained himself and family by giving lectures on different subjects relating to jurisprudence; and his mother's brother, Dr. G. R. Pommer, by lecturing on the practical parts of the same science. Both of them, however, had more taste for literary pursuits than for that from which they derived their support. The latter understood the French, English, Italian, and Spanish, and by these means young Kästner had an opportunity of learning these languages. Pommer possessed also a considerable collection of books in these languages, and, as Kästner had early acquired a taste for reading, he made use of it, as well as of his father's library, as far as his talents would admit. As it is impossible to read much, even in historical events, whether real or feigned, without meeting with allusions to the mathematical sciences; Robinson Crusoe having fallen into our young mathematician's hands, he learned with great avidity the nautical terms which occur in that popular romance, and of which an explanation is given in the German translation.

In the year 1731, he attended the philosophical lectures of the celebrated Winkler, and next year studied mathematics under G. F. Richter. At this period he purchased at auctions as many books as he could, and he received many as presents from his uncle. In regard to his knowledge of general mathematics, he derived great benefit from the works of Wolfe; and he acquired a good notion of astronomy from *Erasmi Francisci Eröffnetes Lusthaus der Ober-und Nieder-Welt*, printed at Nürnberg in 1676; a work which Kästner considered as a compilation formed with great care and judgment.



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In the year 1735 he ſtudied under Hauſen, and he uſed to thank this preceptor for having recommended to him the Greek method of geometry, which is ſo certain, and which Käſtner afterwards purſued with ſo much credit to himſelf.

At this period there was very little encouragement at Leipſic for practical aſtronomy. Hauſen ſometimes ſhowed the moon to his pupils through a teleſcope, and young Käſtner once obſerved in his company an eclipſe of that planet; but they had no time-piece, and their only teleſcope was borrowed from Walzen, a native of Wirtemberg, who reſided at Leipſic as a private tutor, and who was afterwards geographer royal at Dreſden, where he died. Another time Hauſen carried Käſtner along with him to the tower of Saint Nicholas's church to obſerve a tranſit of Mercury over the ſun, and for determining the time they had a plummet ſuſpended by a thread; but, the weather being cloudy, they could make no obſervation. In the year 1742 a comet appeared, and Hauſen determined its orbit in the ſimpleſt manner, by the interſection of two arches through two pair of ſtars. A projection of this comet's orbit may be ſeen in Gottſched's preface to Heyne's *Verſuch einer Betrachtung über die Cometen*; Berlin, 1742. Young Käſtner being deſirous of obſerving, along with ſome friends, this comet through a teleſcope, applied to his tutor, who gave him an old wooden tube, and a convex glaſs to be uſed as an eye-glaſs, by holding it to the end of the tube with the hand. What obſervations the company could make with this inſtrument it would be difficult to ſay in proſe; but Käſtner himſelf has given an account of them in an ode publiſhed in the firſt part of his Miſcellanies.

From what has been ſaid it may readily be conceived what progreſs Käſtner was able to make in practical aſtronomy. Being left entirely to his own aſſiduity, he procured Doppelmayr's chart of the ſtars and Bayer's Uranometria; and often repaired to the market-place of Leipſic, and other convenient ſtations, to obſerve the heavenly bodies. In the year 1742 he formed an acquaintance with I. C. Baumann, who by his own induſtry had ſtudied mathematics in the writings of Wolfe, and who wiſhed to ſee himſelf what he had learned

from

from these and other books; but he had no money to purchase instruments and telescopes. He therefore did what has been since practised by Herschel: he constructed some himself, according to the directions given by Hertel and Leutmann. Baumann's sister, whom Kästner afterwards married, recommended herself to his notice by her attachment to these pursuits.

Having obtained from Baumann a telescope the object-glass of which had a focus of six feet, and which magnified 23 times, he employed it for observing the comet of 1744, much better than the one he had borrowed in 1742. He had no time-keeper, but he purchased at a sale a brass quadrant of half a Rhinland foot radius, with fixed sights, and divided into quarters of a degree.

In the course of time he caused more and larger telescopes to be constructed, which he employed as far as could be possibly done where he had no means to determine accurately the time. With a 26 feet telescope of this kind, he saw in the sun, as he assures us himself, white luminous spots, such as Mr. Schröter of Lilienthal observed afterwards with the best telescopes. With the same telescope Baumann observed a dark red ring round Mercury during his transit over the sun on the 6th of May 1753. On the 9th of October 1751, Kästner observed an occultation of Jupiter; and on the 11th of February, next year, one of Venus by the moon: of both these phænomena, and the circumstances attending them, he published an account in the eighth volume of the Hamburgh Magazine. It may there be seen that at this period he employed himself in observing the heavens as much as his situation would admit.

In the year 1737 he had begun to learn algebra with Heinsius. Next year, Heinsius, having finished his course, made a tour to Petersburgh, and on his return in 1745 Kästner requested leave to be present at the observatory while he made his observations; but he could not get his wishes gratified. In this point Heinsius was exceedingly reserved, and it was only with great difficulty that baron Kregel could obtain a similar favour. In other respects Kästner kept up a very friendly intercourse with Heinsius.

In the year 1755, when the celebrated Lieberkuhn, to whom optics and physiology are so much indebted, was called in as a physician to visit an old duchess who resided at Leipsic; he paid a visit to Kästner, and presented him with two object-glasses, one of 27 feet 6 inches focus, and the other of 11 feet, which Kästner kept by him as long as he lived.

After the year 1746, Kästner enjoyed a salary of 100 rix-dollars as extraordinary professor: what was further necessary for maintaining himself and family, he procured by his lectures and by labouring for the booksellers. By translating the Swedish Transactions, contributing towards the Hamburgh Magazine, publishing an edition of Smith's Optics, and translating Lulolf's Knowledge of the Terrestrial Globe, he had a further opportunity of improving himself in astronomical knowledge; but he was not able to employ so much time in the pursuit of this science as he wished; and he wanted instruments, as well as a proper place, for making astronomical observations.

Kästner had hopes of obtaining the first philosophical chair that should become vacant at Leipsic; but, as he could not wait till Heinsius or Winkler should make room for him, he left that city, and in the year 1756, after Segner's departure from Göttingen, was invited thither to be professor of mathematics and natural philosophy.

At that period Göttingen afforded many excellent opportunities for improvement in the mathematical, astronomical, and physical sciences. Tobias Mayer had been invited thither after Penther's death; and Lowitz, Wehner, Müller, Meister, Eberhard, and Hollmann, taught every branch of the mathematical and physical sciences. Mayer, in particular, showed great friendship to Kästner; but he gave him no opportunity of participating in his labours at the observatory.

In his occupations Kästner was assisted by Baumann, who had followed him to Göttingen as optician to the university, and who was of great service to the observatory by constructing for it instruments and achromatic telescopes; but the unsettled state of affairs during the seven years war, by which Göttingen was much affected, was not favourable to astronomical observations.

A geo-

A geographer and astronomer being wanted to accompany the travellers sent at the expense of the Danish government to the East, in consequence of a proposition made by Michaëlis, Mayer recommended one of his scholars; but as he refused the offer, Kästner recommended Niebuhr, one of his pupils, who was destined to be an engineer. Niebuhr agreed to the proposal, but was under the necessity of obtaining instruction in two branches of knowledge which he did not before consider as necessary to his views: he was obliged to learn Arabic with Michaëlis, and to make astronomical observations under Mayer. How well he employed his knowledge in these respects may be seen by the account of his travels; and it may with justice be said, that the successful result of the expedition was in a great measure owing to Kästner.

Kästner having received a rescript from Hanover, in which it was stated that, the observatory not being employed for the benefit of the university, as was wished, if he would agree to take a share in it he should be allowed the free use of it along with Mayer; he returned for answer, that "as Mayer's great service to astronomy was well known, he could not see how the observatory could be employed to better advantage than under his direction." When Kästner had sent off this answer, he transmitted a copy of it, along with the rescript, to Mayer, who was highly satisfied with his conduct on the occasion. Mayer at the same time said, that if any other person had been suffered to participate with him in the care of the observatory, he should have resigned his office altogether; adding, that "it would be an unfortunate thing for a man to become old in Göttingen." Mayer, indeed, did not live to become old, for he died three days after he had completed his 39th year. Kästner was then secretary of the Royal Society of Göttingen, and on the 13th of March 1762 he read before that body an eulogy on Mayer, which he afterwards published.

After Mayer's death, the care of making observations was committed to Lowitz, who at the same time received an increase of his salary; and Kästner was appointed to assist him. Lowitz, however, would not accept of Kästner in that capacity, and the latter did not choose to importune him. In year 1763 Lowitz made known his reſolution of leaving Göttingen, and reſigned the obſervatory to Käſtner, with every thing it contained. Though Käſtner had before nothing to do with the obſervatory, he gladly aſſumed this new occupation; but it was an expreſs condition on entering upon it, that he ſhould require no increaſe of his ſalary; a ſacrifice which he readily made, eſpecially as he had before found no difficulty, when in a leſs favourable ſituation at Leipſic, to incur conſiderable expenſe in order to gratify his taſte for aſtronomy. The confidence repoſed in him on this occaſion he employed to the benefit of aſtronomy and the honour of Göttingen, by cauſing the manuſcripts left by Mayer, and his drawings of the moon, to be purchaſed for the uſe of the univerſity. Theſe he preſerved at the univerſity till they were delivered into the hands of Lichtenberg for publication; and thoſe not publiſhed were after his death depoſited in the public library.

Käſtner had neither occaſion, time, nor inclination, to acquire the ſame dexterity as Mayer: he obtained the uſe of the obſervatory when he was five years older than Mayer at the time of his death, and only as an addition to his other numerous occupations. He did not therefore pretend to great readineſs in the management of the inſtruments, which requires long and uninterrupted experience; but it may be ſeen by his works that he underſtood every thing in regard to making obſervations, and that his former practice was of great uſe to him.

The firſt who, under Käſtner's direction, took advantage of the permiſſion given to uſe the obſervatory, were Kügel, Lichtenberg, and Ljungberg. The laſt was much inclined to devote himſelf entirely to aſtronomy: by Käſtner's recommendation he was appointed profeſſor of the mathematics at Kiel, and is now a counſellor of ſtate to his Daniſh majeſty at Copenhagen.

On the 19th of June 1769, when the tranſit of Venus over the ſun took place, Käſtner, in company with Lichtenberg and Ljungberg, obſerved as much of that phænomenon as could be ſeen at Göttingen; that is, the ingreſs of the planet into the ſetting ſun.

In the year 1771, Lichtenberg, in consequence of a proposal made by Käftner, was appointed to make obfervations for determining the geographical fituation of different places in the electorate of Hanover. He, however, wanted a quadrant; and as Kampe, who had undertaken to conftruct one, proceeded flowly in his labour, Käftner applied to Demainbray, director of the king's private obfervatory at Richmond, who fent him, at the king's defire, a quadrant by Siffon, which Lichtenberg employed, and which he afterwards gave to the obfervatory.

The obfervatory had now obtained an excellent inftrument for correfponding altitudes of the fun; but as obfervations, on account of the nature of the building, could be taken in the morning only on the fouth-eaft fide, and in the afternoon on the fouth-weft, it was neceffary to remove the quadrant each time, and afterwards to adjuft it. This labour was undertaken by H. Opperman; I. T. Mayer, fon of the aftronomer, a counfellor of ftate to his Britifh majefty, and now profeffor at Göttingen in the room of Lichtenberg; and Müller, captain of the Elbe frigate at Stade: but, on a reprefentation made by Käftner, a building was conftructed in the year 1782, under the direction of Opperman, on the fouth fide of the obfervatory, where Siffon's quadrant is now erected, and when ufed it needs only to be turned. A like building has been conftructed on the north fide, for correfponding altitudes of the northern ftars.

Käftner procured from Baumann feveral achromatic telefcopes and a heliometer; and the obfervatory, by the munificence of their prefent majefties, the late duke of York, and the care of the Hanoverian government, was enriched with various telefcopes, among which was one of Herfchel's reflectors, and a clock by Shelton with a compenfation pendulum. A paper of Käftner's refpecting the variations in the going of this clock during the winter of 1778, may be found in Langfdorff's Mechanical and Hydrodynamical Refearches, publifhed in 1788.

In the year 1789, Charles Felix Seyffer was appointed profeffor of aftronomy at Göttingen; and as the practical

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part of this fcience was committed to his care, he was placed under Käftner for inftruction. Since that period all the obfervations at the obfervatory have been made by Seyffer.

Notwithftanding Käftner's fervice to aftronomy and geography, the fervice he rendered to the mathematical fciences in general was much greater; and his name will be mentioned by pofterity among the moft eminent profeffors. He exerted himfelf with the moft celebrated geometers of Germany, Segner and Karften, to reftore to geometry its antient rights, and to introduce more precifion and accuracy of demonftration into the whole of mathematical analyfis. The doctrine of binomials; that of the higher equations; the laws of the equilibrium of two forces on the lever, and their compofition, are fome of the moft important points in the doctrine of mathematical analyfis and mathematics, which Käftner illuftrated and explained in fuch a manner as to excel all his predeceffors. Germany is in particular indebted to him for his claffical works on every part of the pure and practical mathematics. They unite that folidity peculiar to the old Grecian geometry with great brevity and clearnefs, and a fund of erudition, by which Käftner has greatly contributed to promote the ftudy and knowledge of the mathematics. Käftner's talents, however, were not confined to mathematics: his poetical and humorous works, as well as his epigrams, are a proof of the extent of his genius; efpecially as thefe talents feldom fall to the lot of a mathematician. How Käftner acquired a tafte for thefe purfuits, we are told by himfelf in one of his letters. In the early part of his life he refided at Leipfic, among friends who were neither mathematicians nor acquainted with the fciences: he then, as he tells us himfelf, contracted "the bad habit of laughing at others;" but he ufed always to fay, *Hanc veniam damus petimufque viciffim.* Käftner died at Göttingen on the 20th of June 1800, at the age of eighty-one.

Befides works on the pure and practical mathematics, we are indebted to Käftner for a hiftory of the mathematics from the revival of literature to the end of the 18th century. Vol. I. Arithmetic, Algebra, the Elements of Geometry,

 Trigonometry,

Trigonometry, and Practical Geometry, to the end of the 16th century; *Göttingen* 1796. Vol. II. Perspective Geometrical Analysis, and the higher Geometry, Mechanics, Optics, and Astronomy; first period towards the end of the 16th century. Appendix to the first volume, *ibid.* 1797, large octavo.

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## XII. *History of Astronomy for the Year* 1800. *By* JEROME DE LALANDE.

[Concluded from Page 15.]

C. CAROCHÉ finished in the month of May a telescope of 22 feet, constructed without a small mirror, in the same manner as those of Lemaire and Herschel; and he is now employed in making for another a speculum of platina $7\frac{1}{2}$ inches in diameter.

C. Tremel has begun a new stand for the telescope of 22 feet, much firmer and more convenient than those before employed.

A terrace has been begun towards the south on a level with the lower hall of the observatory, for placing the telescope upon when carried out: nothing is wanting to complete it but the last course of the materials.

Brother Noël, a Benedictine, finished, in 1772, a telescope the speculum of which had a focus of 24 feet 4 inches, and which was $22\frac{1}{2}$ inches in diameter*. He pretended that this telescope magnified 430 times; but Sir George Shuckburgh estimated its magnifying power only at 200. Noël valued this instrument at 80,000 francs, but Louis XV. had expended upon it more than 500,000.

The small speculum was convex, in imitation of Cassegrain's, and had five feet real focus; which made the length of the telescope less. The eye-glasses of 8 and 24 inches focus could magnify 528 times; but it was not sufficiently good to bear that degree of power.

He mistrusted astronomers, and would not suffer me to view Jupiter through his telescope: "If you find it a good one," said he, "you will add nothing to my credit, for I am al-

* *Connoissances des Temps* 1775, p. 339.

 lowed

lowed all that I require; and if you find it a bad one, you may do me a great deal of hurt."

Brother Noël was a tallow-chandler of Amiens, who had become bankrupt; but, having an opportunity of making himself known to the duke de Chaulnes, at his seat in Picardy, he imposed on him by his loquacity, and the duke introduced him at court to exhibit a microscope which in all probability he had never made. He got a lodging at the Abbaye; he associated himself with Navarre, who was a good optician; and he proposed to the king to undertake a telescope, only 12 feet in length, which should have a magnifying power double to the great telescope of Herschel. He was afterwards allowed to reside in the hotel de Passy, near the castle of La Muette, where he laboured till his death, which took place in 1781.

Rochon, who succeeded him, sent for Caroché, who had already given proofs of his ability, and who, having re-polished the mirror, rendered this telescope as good as that of Herschel: this Mechain and myself proved in 1788.

The observatory will now be as well furnished with instruments as any in Europe.

C. Janvier, a celebrated watch-maker, has presented to the Institute a beautiful clock, in which he has represented, by new and ingenious means, things difficult to be expressed in machinery, such as the nodes of the moon, the precession of the equinoxes, and the two parts of the equation of time. He presented also, not long ago, another new machine, which contains new inventions for eclipses, the tides, the satellites, the annual parallaxes, the true motion of the heavenly bodies; and where these complex movements do no injury to the moving force of the regulating wheels.

The king of England has given 3000 guineas to Mr. Schrœter, of Lilienthal, for his instruments, which in future will be considered as the property of the university of Göttingen.

The duke of Gotha has procured for his excellent observatory a three-feet circle made by Troughton, who in that line vies with Ramsden: this circle cost 10,000 francs. He has bespoke a large sector for making observations in the zenith, and a telescope of 16 feet from Mr. Schrœter. He has carried

ried his zeal and munificence so far as to cause to be constructed, for Mr. Wurm, a telescope of 7 feet, that he may be enabled to gratify his taste and to exercise his talents for astronomy. The duke of Gotha has obtained also from Paris an equatorial instrument by Ramsden, the circles of which are an inch in diameter, and which is accurate to 30″. It is that which I caused to be made for Bergeret, and which was afterwards purchased by Patu de Mello, who had a singular though barren taste for possessing fine instruments and good books. Besides others, he had the observations of Hevelius, of which only ninety copies were left, the rest of the edition having been burnt by the villainy of an infamous wretch in 1679. This volume has been purchased by C. Labbey, professor of mathematics in the central school of the Pantheon, with all the other works of Hevelius, which he is worthy to possess.

Patu de Mello had two equatorials, excellent achromatic telescopes, and beautiful clocks; but he would never suffer any one to use them, nor even to see them. In this respect he was very different from the president Du Saron, who took a pleasure in lending his most valuable instruments; and from Bergeret, who lent us his large mural quadrant for the Military School, where it still remains.

Troughton has already made fifty circles in imitation of ours, with some changes and useful improvements. He did not think that his being an Englishman ought to prevent him from taking advantage of an invention which principally belongs to France.

The king of Prussia has granted 20,000 francs to the observatory of Berlin, where M. Bode was in want of many important articles. A meridian telescope of 3½ feet, by Dollond, has been procured; and a new hall has been prepared above that where I erected the mural in 1751. A description and figure of this observatory may be seen in Bode's Ephemerides for 1804.

Adjutant-commandant Abancourt is employed, by order of the commander in chief, in constructing a map of Bavaria on the same scale as the large map of France; and he has sent us the foundations of his labour. This map will connect

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with that of Swabia, constructed on the same scale by Messrs. Bohnenberger and Amman.

M. Delecoq is constructing one of Westphalia: that of the Netherlands, on the same scale, has been finished: thus the example of the French has become fruitful, and even the English are preparing to follow it.

The Academy of Stockholm has sent M. Svanberg to Tornea to examine the stations where the French academicians carried on their operations in 1735, for measuring a degree of the meridian. As this degree seems to be too large, some errors are supposed to have taken place; and a design is in agitation for re-measuring it. As sensible irregularities have been found in the degrees of the meridian between Dunkirk and Barcelona, it would not be surprising that there should be some at the 66th degree of latitude.

The king of Denmark has established a board of longitude, of which professor Bugge is director, with two assistants. This establishment was chiefly owing to M. Lowenhorn. Ephemerides for 1803 are going to be calculated, which will contain the distance of the moon from the planets. M. Wurbierg gives lectures there on astronomy; and pupils are now instructing, in order to be sent to Iceland to form a map of that country.

M. Von Zach, who every year, in autumn, makes a geographical and astronomical tour through Germany, has determined the position of Brunswick to be 52° 15′ 43″ and 32′ 37″ east of Paris.

At Zell, in the duchy of Lunebourg, M. Von Ende, counsellor of the supreme court of appeal at Hanover, who possesses a well furnished observatory, has determined its position to be 52° 37′ 47″ and 30′ 5″.

M. Olbers, at Bremen, has determined that city to be 33° 4′ 37″ and 25′ 48″. He is more and more confirmed in opinion that the place of the moon may be determined within 5 or 6″ by a sextant of 9 inches as well as with the best instruments. Bremen, which is a large free hanse-town, has enabled M. Olbers, in consequence of his zeal, to form an association of opulent people and merchants, who have established

established a musæum, a cabinet of philosophical instruments, and an observatory, with professors. Dr. Olbers has been appointed professor of astronomy.

At Lilienthal, M. Von Zach was astonished at the immense number of instruments in the possession of M. Schrœter. One of his telescopes is 27 feet in length; but he has another of 13 feet, which is perhaps the best in the world; it produces effects that have astonished one of our ablest observers. M. Schrœter's gardener, who is a man of great ingenuity, casts specula, and polishes them with wonderful dexterity. His telescopes of 7 feet will bear to be compared with those of Herschel. He has established a very extraordinary manufactory, where astronomers may be supplied with a speculum of 4 feet focus, and a small plain speculum, at the price of 120 francs; and a speculum of 15 feet focus for 700 francs. This is not the tenth part of what was usually demanded for such articles at London and at Paris. M. Schrœter has made observations of Mercury, the rotation of which he believes to be 24 h. 5′. On this subject he intends publishing hermographic fragments. In regard to astronomy, he has a privileged sight; he can distinguish Mercury in the open day by the naked eye; he has several times seen in his telescope small stars shooting along like a delicate streak of very faint light, which lasted 2 or 3″; this proves that the hydrogen and oxygen of the atmosphere extend to the distance of several leagues: meteors or globes of fire, which excite astonishment when at the distance of a few hundred fathoms, become shooting stars when at the distance of a league, and telescopic stars at three or four leagues.

Prince Adolphus, the tenth child of his Britannic majesty, aged 27, who is very studious and well informed, contributes towards the peculiar protection granted by his father to astronomy in the electorate of Hanover; he paid a visit at the same time as M. Von Zach to the observatory of Lilienthal. M. Harding has been appointed assistant to M. Schrœter, with a salary from the king.

M. Von Zach every where found zeal for astronomy, and he every where contributed to increase it: details on this subject may be seen in the excellent journal which he pub-
lishes

lishes every month. In this journal portraits of those able astronomers Delambre, Mechain, Burg, and Duc-Lachapelle, have been given, together with an account of their labours. Those of Mechain are very considerable.

M. Bogdanich undertook also a similar tour, and on his return brought back a great many determinations.

Our knowledge of the geography of distant countries has been considerably enlarged by the voyages of Vancouver and Marchand round the world: that of the latter has been published by Fleurieu in four volumes quarto. To these we may add Symes's embassy to Ava, Park's travels in Africa; those of Brown, who was as far as Darfoor in the interior of Negritia; those of Horneman, to whom general Bonaparte procured the means of penetrating thither, and who has already sent home his journal; and those of Damberger, who spent several years in Africa, which have been published at Leipsic with a curious map of Africa by M. Goldbach: they are now translating into French. When I published my Memoir on Africa in 1791, nothing was known of that immense country. By collecting a few facts I endeavoured to excite emulation and curiosity; and my wishes are already in a great measure accomplished.

Vaillant proposes to return to Africa, where he has already distinguished himself; and a company of merchants at Marseilles have announced an establishment on the eastern coast of that country.

Seventeen charts of the coasts of South America and of the gulph of Mexico have been published at the Repository of the Spanish Marine established in 1791. Nautical tables have been published by Mendoza, and memoirs respecting navigation by Lopez Royo and Galiano. Joseph de Spinosa, captain in the royal navy and director of the repository, has done every thing to render himself useful; and there is reason to hope for great things from his intelligence and zeal.

We have received also an account of the voyage undertaken to the straits of Magellan in 1785 and 1786 by Don Antonio de Cordoba, Don Dionisio Alcala Galiano, and Don Alexander Belmonte, with a great many charts and observations.

 M. Rossel

M. Roffel is employed in England in arranging the journal of his voyage with d'Entrecafteaux, which he purpofes to publifh. M. Lagrandiere, another officer belonging to the fame expedition, has alfo a journal; and it is probable that the Britifh government, to whom it was communicated, made ufe of it for the chart of New Holland lately publifhed.

C. Meignien, now at Madrid, has had the courage to tranflate into French four Spanifh works relating to navigation, and has fent the manufcripts to the Repofitory of the Marine at Paris.

I fhall fay nothing of the great number of new charts and maps which have appeared in England and Germany: they have been announced in the General Journal of Foreign Literature, edited by M. Loos, and publifhed by Treuttel and Wurtz at Paris. This journal is an immenfe repofitory of books, which without its aid would be unknown to us.

The General Journal of French Literature, publifhed by the fame bookfellers, is alfo of importance on account of the great care they take to omit nothing. The firft year contains 1680 articles.

We ought to mention alfo the Literary Notices, or fpirit of the foreign journals, printed for Kœnig at Paris and at Strafburg, which contain interefting information in regard to aftronomy.

We have received from Humboldt obfervations made in South America, to which he has been conducted by the love of fcience. His knowledge in aftronomy, natural philofophy and natural hiftory, his zeal and his fortune, all equally contribute to render his travels interefting.

The Memoirs refpecting the Marine, by A. Thevenard, vice-admiral, publifhed in the month of November by Laurens, in four volumes octavo, contain various articles on geography, and one in particular on Cape Circumcifion, which gave occafion to a difcuffion between me and the illuftrious author, which was publifhed in the *Connoiffance des Temps* for 1798.

I. B. Le Chevalier has publifhed a defcription of the Propontis, the Pontus Euxinus, the Bofphorus, and the channel

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of Constantinople, where he made observations when with the French ambassador Choiseul-Gouffier.

The English have announced that a vessel, called the Lady Nelson, is about to set out on a voyage round the world for the improvement of science.

Nouet has sent us a table of the positions of 35 cities in Egypt, as far as Syena, which he finds to be in 24° 8′, though it was long believed to lie under the tropic.

We learn from a memoir transmitted by C. Coraboeuf, engineer in Egypt, that the Egyptians, on two zodiacs found at Henné in 25°, and at Dindara in 26° north latitude, had indicated the solstice, first placed in the constellation of Virgo, then in Leo, and approaching Cancer.

C. Grobert, chief of the brigade of artillery, has published a description of the pyramids of Ghizé and of the city of Cairo: it contains an astronomical note by Burckhardt, who, having seen a drawing, made by Denon, of the zodiac of Dindara, finds that the solstice had advanced 60° further than the place where it now is; which supposes an antiquity of 4000 years. By studying the surrounding figures, this position may be obtained with more accuracy.

C. Fournier has presented to the Institute of Egypt a memoir containing further details.

The zodiac of Henné or Esna is much older; the solstice there is in the constellation of Virgo, which supposes an antiquity of 7000 years. But the position of the solstice is there indicated in a more vague manner, and it is not impossible that there may be an uncertainty of some hundred years. This, however, still appears to give some degree of probability to the hypothesis of Dupuis, mentioned in the fourth volume of my Astronomy, who ascribes our zodiac to the climate of Egypt when the summer solstice was in the constellation of Capricorn 14 or 15,000 years before our æra; and who finds that the Indian zodiac, which Bailly caused to be engraved, goes back also 7000 years.

The zodiac of Henné was found by general Dessaix, Fourier, and Costas, after the departure of Denon. But Coraboeuf says in his letter that the zodiac indicates the solstice

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in Virgo. What he calls a sign we call a constellation. General Menou announces a new journey, 150 leagues further. We are assured that there are other Egyptian antiquities; and the men of letters who go thither will perhaps discover a zodiac of greater antiquity than that of Henné.

C. Coraboeuf, when he says that the large pyramid of Memphis declines 20 minutes to the north-west, adds, that Picard found 18′ deviation in the meridian of Tycho. As an astronomer I ought to add, that Picard was mistaken by taking one tower of Elsineur for another, as M. Augustin has shown in the twelfth volume of the old Memoirs of the Academy of Sciences at Copenhagen.

The voyage undertaken by the corvettes *le Geographe* and *le Naturaliste*, captains Baudin and Hamelin, shows the attention of government to the sciences. The plan was in agitation for several years. Captain Baudin, having brought from America, four years ago, a large collection of plants and insects, when he made a voyage in *la Belle Angelique* with Le Dru, the Parisian naturalists were exceedingly desirous that he should undertake another, on a larger scale, round the world, or, at least, to countries little known, which might be more important and more productive.

In the month of February he came to Paris to solicit in favour of this enterprise: the astronomers united with the naturalists to point out the advantages of it, and they even pretended to the most important part of the expedition. Geography has so many departments which demand our attention, that we could not help seizing this opportunity of supplying some deficiencies in it; and the French people, who are determined to have a navy, wish to obtain certain data in every sea, and to be able to assist navigators in every country. This is a great and an immense labour; a few plants and insects more is the least important part of the voyage. Some persons were of opinion that it ought to be deferred till the conclusion of a peace; but the first consul, who sees no difficulties when grand objects are in view, was desirous they should set out as soon as possible. At ten in the morning, October the 19th, our navigators left Havre-de-Grace, directing their course northwards, and at ten in the evening

 had

had proceeded from 30 to 35 leagues, notwithstanding the delay of an hour, occasioned by a visit from the English. There is every reason to think that they got clear of the channel in two days. M. Belfin, who accompanied them till two in the morning, was highly pleased with their unanimity, their eagerness, and joy. Captain Hamelin is loved and esteemed by every body; in a word, the whole of the people on board *le Naturaliste* seemed to form only one family.

The Board of Longitude, in concert with the commissioners of the Institute, chose for this expedition two astronomers, Frederic de Bissy, born at London May 10, 1768, who had laboured in my observatory at the military school from 1795 to 1798; and P. Francis Bernier, born at Rochelle November 10, 1779, who, after being instructed at Montauban under Duc-Lachapelle, laboured for eight months with great success in my observatory at the *College de France*, and who has exercised himself in nautical astronomy with great assiduity. He will soon be accustomed to observe on board ship: his zeal and intelligence give me the greatest hopes respecting him; and I have already seen with pleasure an eulogy on him in the *Journal de Paris*.

This young astronomer has not forgot the care I took of him: I learn so by reading in one of the journals, that, during an entertainment given by the officers to the men of science, when the Republic and the Navy had been drunk, Bernier said, with a tender effusion of gratitude, "To those who have guided us in the career of science." This toast, worthy of his sensibility, was received with satisfaction by all the guests.

I had proposed another astronomer, C. Louis Ciccolini, born at Macerata on the 22d of November 1767, a knight of Malta, who had laboured with me two years, and several of whose calculations I published in the *Connoissance des Temps*; but he was not a Frenchman, and this reason seemed decisive, particularly at a time when the French were desirous of showing their zeal. I in vain attempted to destroy this prejudice. In a word, I have seen with pleasure that all the three were exceedingly desirous to undertake the voyage, notwithstanding the dangers of every kind with which it must

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be attended. General Bougainville had the courage to send on board one of his sons, Hyacinth, born on the 26th of December 1781, who is beginning, in an honourable manner, to tread in the steps of his illustrious father. We expected that Maingon and Quenot, well known as astronomers, would have had a share in the expedition; but the former was prevented by indisposition, and the latter would not depart without him.

The naturalists say, that the flax of New Zealand will be sufficient to indemnify the state for the expense of this expedition; and the astronomers will find themselves sufficiently rewarded by some positions to the south of New Holland and on the coasts of Africa. But a voyage of two or three years cannot fail to furnish science with a number of new facts.

A most singular meteorological phænomenon is the hurricane of the 9th of November, which ravaged the whole country from Brittany to Holland, and from Burgundy to England; it destroyed a great number of vessels in the Channel, but our navigators had got out of it long before that time.

The loss I sustained in C. Bernier has been repaired by Michael Chabrol, born at Riom on the 18th of November 1777. In the month of May he came to Paris to reinforce astronomy, which had need of his assistance. He has already calculated a great many eclipses, positions of stars, and the longitudes, latitudes, and angles of position, of 600 of the principal stars, which form the fundamental catalogue inserted in the *Connoissance des Temps*, and which Le François-Lalande has further improved by observing the right ascension and declination of those which before were not fully known.

Considering the scarcity of astronomers, we ought to applaud Lancelin, professor at Brest, who propagates nautical astronomy with wonderful zeal: he has formed pupils, who will be of the utmost utility to us when our marine shall have acquired that activity which the French government intends, and is preparing, to give it.

C. Henri has left Petersburgh to return to France. The decree in favour of the French emigrants exiled from their country will procure us the return of this able astronomer.

Slop, a celebrated astronomer of Pisa, has been arrested in consequence of the troubles in Tuscany; but the French have entered that country, and there is reason to believe that this astronomer will be restored to his observatory.

On the 14th of July the fire-works at Dijon, on account of the festival, having been placed on the top of the observatory, occasioned a conflagration, which damaged the instruments, and particularly the speculum of a Herschel's telescope; but professor Jacotot has still a sufficiency to make useful observations.

Montucla, who died on the 19th of December 1799, after having published the History of the Mathematics up to 1700, in two volumes, had prepared a continuation of that work, comprehending the 18th century. Three hundred pages of the third volume were even printed; but the remainder of the copy was not finished, and especially that part which relates to mechanics and astronomy. Defortia has taken upon him the optical part, and I have engaged to revise the astronomical, and to complete and publish the whole. I thought this care due to one of my oldest friends, whom I forced, as I may say, to give this new edition.

C. Montjoye has published an eulogy on the first president Du Saron, who was an able astronomer. He has added some interesting details, furnished by Messier and myself, and with which I was unacquainted when I gave his eulogy in the History of Astronomy for 1794, a year of crimes and misfortunes.

On the 20th of June 1800, we lost at Göttingen Abraham Kästner, who was born at Leipsic on the 27th of September 1719. He was director of the observatory after the death of Mayer and Lichtenberg. He was as celebrated as a mathematician as a man of letters, and published several memoirs on astronomy, both in German and Latin, in the Transactions of the Society of Göttingen. Some details respecting him may be found in Von Zach's Journal for July *. His life has been printed at Leipsic in an university oration spoken in the fiftieth year of his reception.

On the 28th of December 1800, we lost also James

* Our readers will find them in the beginning of this number of the Philosophical Magazine.

Anthony

Anthony Joseph Cousin, who in 1787 published an excellent introduction to physical astronomy, containing learned and useful calculations.

John Albert Euler, son of the celebrated Leonard Euler, died at Petersburgh on the 6th of September, at the age of 66. Several memoirs on astronomy, written by him, may be found among the prize questions of the Academy of Sciences, and in the Transactions of the Academy of Petersburgh.

On the 22d of April we lost at Thoulouse Jerome Hadancourt, born in that city in 1748, who laboured for several years with Darquier, as may be seen at the head of his observations. Four years ago he had been entrusted with the observatory of Thoulouse, which Garipuy caused to be built in 1775; but he could not make use of it for more than three years. The gout and other maladies conducted him to the grave. His eulogy may be found in the Magazine *Encyclopedique*, 6th year, vol. iv. His place has been supplied by Vidal.

Kœhler died at Dresden on the 19th of September, at the age of 55.

Hanna died at Pekin: he is the last, I believe, of the Chinese astronomers. The general of St. Lazarus, desirous to fill up this department of the missionary establishment, placed him under my care to study astronomy: he was met near Pekin by the English, as may be seen in the account of Lord Macartney's embassy to China.

Arnold, the celebrated watch-maker, died at London; but his son continues to make time-pieces, chronometers, and regulators.

We have lost Mentelle, the engineer, who resided at Cayenne since 1763, when the duke De Choiseul sent thither 10,000 settlers; he was brother to the celebrated geographer, and we had received from him last year observations on the flux and reflux of the sea.

Monneron sen. who had been in India, and who brought with him some memoirs on the astronomy of the Indians, died at Annonay.

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The abbot of Cremſmunſter, Erembertus, died in his abbey on the 29th of March. The ſervice he did to aſtronomy we have mentioned in another place. It was to him that Fixlmuller dedicated in 1776 his work entitled *Decennium Aſtronomicum*. Profeſſor Wolfgang Leuthner, his ſucceſſor, ſhows the ſame deſire to ſupport aſtronomy in that abbey which Fixlmuller rendered celebrated.

We have loſt at Peterſburgh M. Soimonof, ſenator and preſident of the council of commerce, who had an obſervatory and a great many inſtruments, and who was going to eſtabliſh another at his country-ſeat near Moſcow. He poſſeſſed knowledge and zeal, ſtill very rare in Ruſſia.

Such have been the loſſes ſuſtained by aſtronomy; but it may be ſeen in this account that we have the pleaſure of reckoning among our fellow-labourers ſome men of great merit, and of having juſt reaſon to hope for further ſucceſs. In a word, aſtronomy, as we may ſay, is now complete, ſince, if we except comets, all the celeſtial bodies have been ſubjected to calculation; and it appears at preſent that we have little more to deſire. But, as Seneca ſays, there will always be ſomething to do: *Et poſt mille ſæcula non deerit occaſio aliquid adhuc adjiciendi.*

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## XIII. *Tranſlation of a Memoir on a new Species of Siren.* *By* M. De Beauvois *.

AMPHIBIOUS animals properly ſo called, ſo dreadful and hideous to the vulgar, but ſo different to the eyes of the naturaliſt, to whom all the productions of nature are equally intereſting, offer us an infinite ſcope for diſcovery. Naturaliſts, therefore, not ſtopped by the thoughtleſs repugnance of the vulgar to animals infinitely leſs dangerous than they ſuppoſe, and conſiderably more uſeful than ignorance (which is continually aſking, to what purpoſe are all theſe things?) can imagine; naturaliſts, I ſay, have left us data reſpecting theſe beings,

* From the *Tranſactions of the American Philoſophical Society for* 1799.

beings, which, with time, muſt lead us to a more correct knowledge of, and a more intimate acquaintance with, them. The animal to be treated of in this memoir is a proof of what I advance.

In examining Mr. Peale's collection, I had occaſion to remark amongſt the amphibiæ one which I have not ſeen deſcribed by any author. It appeared to me entirely new, and the more intereſting as tending to determine our ideas of the inguana, which has by ſome been claſſed amongſt the amphibiæ, by others with fiſh; but which we find to be an intermediate claſs connecting theſe two.

After having examined, deſcribed, and drawn this new animal, Mr. Peale and I have thought proper to ſpeak of it to this Society before the publication of his catalogue, which will ſoon take place.

Linnæus, the celebrated Linnæus, whom jealouſy is ſometimes pleaſed to criticiſe generally without cauſe; Linnæus, whoſe errors, always exaggerated by his detractors, are (let my admiration for the merits of this great man excuſe the expreſſion) for the greater part marked with a ray of genius; Linnæus, I ſay, had formed a ſeparate order of the inguana (A) diſcovered in South Carolina by Dr. Garden, ſince whoſe death other naturaliſts, amongſt whom was Compfer, (B) have made ſome new obſervations reſpecting it. It was regarded by him, Bonnaterre, (B) and Gmelin, the laſt editor of the works of Linnæus, as a fiſh. The latter naturaliſt conſequently ſuppreſſed the order of meantes; and the *Siren lacertina* is now found placed amongſt the muræna under the name of *Muræna Siren*. Although this animal has much analogy to a fiſh, being furniſhed with gills, Gmelin has obſerved that, in the formation of them, the inguana and muræna are diſtinguiſhable by the numbers of rays. He therefore ſuppoſes it ſhould be placed amongſt the branchioſtegæ, whatever relation it might otherwiſe have with the muræna.

Such is the laſt opinion reſpecting the inguana, (C) of which we will give a deſcription in order that we may compare it with that of the new animal which is principally the object of this memoir.

*Deſcription*

*Description of the Inguana, called* Mud Inguana *by the Americans,* Siren lacertina *by Linnæus, and* Muræna Siren *by Gmelin.*

Head flat at top, rounded at the nose, eyes small, nostrils small and placed near the end of the snout, which is sometimes marked with a brown spot; colour chestnut: (Plate IV.) fig. 1. ABCD.

Mouth furnished with a row of small teeth: fig. 2. Auricular hole nearly in the form of a semicircle, furnished on the exterior with three short, thick, fringed lobes, adhering to three serrated rays on the interior with opercula: fig. 1. E.

Only two short fore-feet, each furnished with four toes, terminated each by a small sharp nail: fig. 1. F.

Body nearly round, shrunk, and streaked on the sides, covered with small scales thinly spread and faintly seen: fig. 1. G.

Tail flat, furnished both above and below with a simple membrane, without either points or prickles: fig. 1. H.

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*Description of a new Animal found in a Swamp in Jersey near the Delaware, not very distant from the Middle Ferry opposite the City of Philadelphia.*

Head flat, rounded at its extremity; eyes and nostrils as in the former, except that the latter are rather nearer together: fig. 3. ABCD.

Mouth large, extending further back than the eyes, furnished with a row of small teeth as in the former: fig. 3. E.

Auricular hole large, bordered on the upper part by three sharp fringed lobes, adhering at one end to three serrated rays placed in the interior, and of which they are a continuation: fig. 3. F.

Under the head two opercula united, forming but one piece: fig. 4. Four feet, those before furnished with four toes, those behind with five. I presume they were furnished with nails; the animal being preserved in spirits of wine has been somewhat changed in its parts: fig. 3. I.

Body somewhat flattened, streaked on the sides, flattest above and below, which gives it a square appearance: fig. 3. G.

4 Tail

Tail flat, furnifhed on the top with a fimple membrane, which commences nearly at the neck, and extends itfelf under the tail as far as the anus: fig. 3. H.

Mr. Peale has preferved the latter animal alive in water for nearly thirty-fix hours, at the end of which time it died. He obferved that as long as it lived it continued fwimming, making ufe of its feet and principally of its tail; that the lobes which terminate the gills were continually floating and in motion; either by a power of motion belonging to them, or perhaps rather the effect of the motion which the animal caufed with its feet and tail, and which was communicated to all parts of the body. He does not recollect whether the *opercula* opened and clofed as in fifh; but, judging from the conformation of thofe parts, I am led to believe they do not.

As long as the inguana only was known, incertitude refpecting its nature might have placed it rather with fifh, to which, it is true, it bears an affinity by an effential character, gills, than with the amphibiæ, to which it feems to belong by all the other parts of its body. But now a new individual of the fame kind, furnifhed with four feet like lizards, feems to indicate that it cannot belong to fifh.

On this difcovery three very important queftions arife. I do not flatter myfelf I fhall be able to refolve them, but will endeavour to difcufs them, and give my opinion.

Are thefe animals fifh? Do they belong to the amphibiæ? Or do they form in the order of nature a new intermediate clafs?

If we form our opinion of the animals we have been defcribing merely from their gills, there is not a doubt but that we muft confider them as fifh. Meffrs. Vicq D'Azir and D'Aubenton afcribe the following characters to fifh: That they are furnifhed with gills which give admittance to the air; that they have not lungs, vifcera which are wanting in all oviparous animals, except birds and the amphibiæ. But if we judge from the entire conformation of all their parts, can we call thofe animals fifh whofe bodies, head, tails, and feet, are fimilar to thofe of lizards? Can we fay with Gmelin, that the feet of the inguana are but digitated pectoral fins? And, in defcribing the new animal upon the fame principles, fhall we call its hind feet digitated abdominal fins? On the other fide, fhall we rank animals, whofe gills are exactly fimilar to thofe of fifh, with lizards? No. I think that both thefe opinions would be equally improper; and it appears to me more natural to believe that thefe animals thus organifed, appertaining in a certain degree to each, fhould form an intermediate and well-marked clafs between lizards and fifh. And until more obfervations be made, and other difcoveries of new individuals fhall enable us to form this clafs, I think it would be beft to revive the order of meantes eftablifhed by Linnæus, and improperly fuppreffed by other naturalifts.

It remains to confider whether thefe animals are of the fame, or whether they form between themfelves a diftinct genus. It is certain that in comparing them fenfible differences may be obferved; but thefe differences appear only fpecific, and fhould yield to the common character of having three exterior fringed lobes attached to three ferrated interior rays, and feet. I will call the firft, then, with Linnæus, *Siren lacertina*, and the other *Siren operculata*.

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## XIV. *A Treatife on the Cultivation of the Vine, and the Method of making Wines.* *By* C. Chaptal.

[Continued from Page 29.]

*Exposure.*—The fame climate, the fame cultivation, and the fame foil, often furnifh wines of very different qualities. We may daily fee fome mountain, the fummit of which is entirely covered with vines, prefent in its different afpects aftonifhing varieties in the wines they produce. Were we to judge of places by comparing the nature of their productions, we fhould be often induced to believe that every climate and every kind of foil has concurred to furnifh productions which, in fact, are only the natural fruit of the fame lands differently expofed.

This difference in the products, arifing from expofure alone, may be obferved in all the effects that depend on vegetation,

getation. Wood cut down in a part of a foreſt looking towards the north, is far leſs combuſtible than that which grows towards the ſouth: odoriferous and ſavoury plants loſe their perfume and ſavour when reared in fat ſoil expoſed to the north. Pliny had obſerved that the wood on the ſouth ſide of the Appenines was of a better quality than that which grew in any other expoſure: and every body knows what the effects of expoſure are in regard to pulſe and fruits.

Theſe phænomena, which are perceptible in regard to all vegetable productions, are particularly ſo in regard to grapes. A vine turned towards the ſouth produces fruit very different from thoſe which look towards the north. The ſurface of the ſoil planted with vines, by being more or leſs inclined, though with the ſame expoſure, preſents alſo modifications without end. The ſummit, the middle, and the bottom of a hill give productions very different. The ſummit, being uncovered, continually receives the impreſſions of every change and of every movement that takes place in the atmoſphere; the winds haraſs the vine in every direction; a more conſtant and more direct impreſſion is made on it by fogs; the temperature is more variable and cold. All theſe circumſtances united, cauſe the grapes there to be leſs abundant; they come with more difficulty, and in a leſs complete manner, to maturity; and the wine ariſing from them is of an inferior quality to that furniſhed by the ſides of the hill, which by their poſition are ſheltered from the greater part of the fatal effects of theſe cauſes. The bottom of the hill, on the other hand, preſents very great inconveniences: the conſtant coolneſs of the ſoil, no doubt, gives the vines great vigour; but the grapes are never ſo saccharine, nor have ſuch an agreeable flavour as thoſe which grow towards the middle region: the air there being conſtantly charged with moiſture, and the ſoil always impregnated with water, enlarge the grapes, and force the vegetation, to the detriment of the quality.

The moſt favourable expoſure for the vine is between the eaſt and the ſouth.

Opportunus ager tepidos qui vergit ad æſtus.

Small hills riſing above a plain interſected by a ſtream of pure water, give the beſt wine; but theſe hills ought not to lie too cloſe to each other:

——————— apertos
Bacchus amat colles ———

A northern expoſure has at all times been conſidered as the moſt fatal: the cold damp winds do not favour the ripening of the grapes; they always remain harſh, ſour, and deſtitute of saccharine principle; and the wine muſt participate in theſe bad qualities.

A ſouth expoſure is alſo not very favourable: the earth, dried by the heat in the day-time, preſents, towards evening, to the oblique rays of the ſun (become almoſt parallel to the horizon) but an arid ſoil deſtitute of all moiſture; the ſun, which by its poſition penetrates then under the vine and darts its rays upon the grapes, which have no longer any ſhelter, dries and heats them, ripens them prematurely, and checks the vegetation before the period of fullneſs and maturity has arrived.

Nothing is more proper to enable us to judge of the effects of expoſure than to obſerve what takes place in a vineyard, the ground of which is unequal, and interſperſed here and there with a few trees: there all expoſures ſeem to be united in one ſpot; all the effects thence depending preſent themſelves to the obſerver. The ſtems of vine ſheltered by the trees throw out long ſlender twigs, which bear little fruit, and lead to ſlow and imperfect maturity. The higheſt portion of the vine is in general the bareſt; vegetation there is leſs vigorous; but the grapes are of a better quality than in low ſituations. The beſt grapes are always found in thoſe places moſt expoſed to the ſouth*.

* The general principles, in regard to the influence of expoſure, admit of many exceptions: the famous vineyards of Epernai and Verſenai, in the mountain of Rheims, are fully expoſed to the north, in a latitude ſo northern for vines, that it is in thoſe places where the region of the vine ſuddenly terminates under that meridian.

The vineyards of Nuits and Beaune, as well as the beſt of Beaugenci and Blois, lie towards the eaſt; thoſe of Loire and Cher lie indiſcriminately towards the north and ſouth; the excellent hills of Saumur face the north; and the beſt vines of Angers are produced from vines which grow in all expoſures.—*Obſervations de Creuzé-Latouche lues à la Societé d'Agriculture de Paris.*

4. *Seaſons.*

4. *Seafons.*—It is well known that the nature of the vine varies according to the character of the feafon; and its effects may be naturally deduced from the principles we have eftablifhed in fpeaking of the influence of climate, foil, and expofure; fince we have fhown how to afcertain what effects moifture, cold, and heat, may have on the formation and quality of the grapes. A cold and rainy feafon, indeed, in a country naturally hot and dry, will produce on the grapes the fame effect as a northern climate: this ftate of the temperature, by bringing together thefe climates, affimilates and identifies all the productions of them.

The vine is fond of warmth, and the grapes never come to perfection but in dry foil expofed to the rays of an ardent fun. When a rainy year keeps the foil in a ftate of continual humidity, and maintains a moift, cold temperature in the atmofphere, the grapes will acquire neither flavour nor faccharine principles; and the wine they produce will be neceffarily abundant, weak, and infipid. Thefe kinds of wine can be preferved with difficulty; the fmall quantity of alcohol which they contain cannot fecure them from decompofition, and the large proportion of extractive matter in them determines movements which continually tend to change their nature. Thefe wines turn oily, and fometimes *four*; but the fmall quantity of alcohol they contain prevents them from forming good vinegar: they all contain a great deal of malic acid, as we fhall prove hereafter, and it is this acid which gives them their peculiar tafte; an acidity which is not acetous, and which forms a more prevailing character in wines in proportion as they are lefs fpiritous.

The influence of the feafons on the vine is fo well known in all countries where vineyards are planted, that, long before the vintage, the nature of the wine may be predicted. In general, when the feafon is cold, the wine is harfh, and has a bad tafte; when rainy, it is abundant, weak, and not at all fpiritous: it is therefore deftined for diftillation, at leaft in the fouth of France, becaufe it would be difagreeable to drink, and difficult to be preferved.

The rains which come on when the vintage approaches are always the moft dangerous: the grapes then have neither

time

time nor fufficient ftrength to mature the juice; and they become filled with a very liquid fluid, which holds in folution too fmall a quantity of fugar for the produce of the decompofition to be either ftrong or fpiritous.

The rains which fall when the grapes are increafing in fize, are exceedingly favourable: they affift the organifation of the vegetable, furnifh it with its principal nutrition, and, if continued heat facilitate the maturation, the quality of the grapes muft be perfect.

Winds are always prejudicial to the vine: they dry up the branches, the grapes, and the foil; and they produce, particularly in ftrong foil, a hard compact cruft, which impedes the free paffage of the air and water, and by thefe means maintains around the roots a putrid moifture which tends to corrupt them. The farmers, therefore, carefully avoid planting vines in fituations expofed to wind: they prefer calm fituations, well fheltered, where the plants may be expofed only to the benign influence of the luminary towards which they are placed.

Fogs are alfo exceedingly dangerous to the vine: they are deftructive to the bloffoms, and do effential hurt to the grapes. Befides the putrid miafmata, which they too often depofit on the productions of the fields, they are always attended with the inconvenience of moiftening the furfaces, and of forming on them a ftratum of water, more fubject to evaporation, as the interior of the plant and the earth are not moiftened in the fame proportion; fo that the rays of the fun, falling upon this light ftratum of moifture, caufe it to evaporate in an inftant; and the fenfation of coolnefs, determined by the act of evaporation, is fucceeded by a heat the more prejudicial as the tranfition is abrupt. It very often happens that the clouds fufpended in the atmofphere, by concentrating the rays of the fun, direct them towards parts of the vines, by which means they are burnt. In the fcorching climates of the fouth it is fometimes obferved that the natural heat of the foil, ftrengthened by the reverberation from certain rocks, or whitifh kinds of foil, dries up the grapes expofed to them.

Though heat be neceffary for ripening the grapes, giving them

them a ſaccharine taſte and a good flavour, it would be erroneous to believe that its action alone can produce every effect required. It can be conſidered only as a mean neceſſary for maturation, which ſuppoſes that the earth is ſufficiently furniſhed with the juices that ought to ſupply the materials. Heat is neceſſary; but this heat muſt not be exerciſed on dried earth, for in that caſe it burns rather than vivifies. The good ſtate of vines, and the good quality of the grapes, depend then on a juſt proportion—a perfect equilibrium between the water, which furniſhes the aliment to the plant, and the heat, that can alone facilitate its maturation.

5. *Culture.*—The vine grows naturally in Florida, America, and almoſt every part of Peru. In the ſouth of France, even almoſt all the hedges abound with wild vines; but the grapes they bear are always ſmaller, and, though they come to maturity, they never acquire the exquiſite taſte of the grapes that are cultivated. The vine then is the work of nature, but art changes its products by bringing the culture of it to perfection. The difference which exiſts at preſent between the cultivated vine and that which grows wild, is the ſame as that eſtabliſhed by art between the vegetables of our gardens and thoſe of the ſame kind which grow accidentally in the fields.

The culture of the vine, however, has its rules as well as its boundaries. The ſoil where it grows requires great care; it muſt be often dug up; but it refuſes the manure neceſſary for other plantations. It muſt here be remarked, that all thoſe cauſes which powerfully concur to give activity to the vegetation of the vine, alter the quality of the grapes; and here, as in other delicate caſes, the culture ought to be directed in ſuch a manner that the plant may receive only poor nouriſhment if grapes of a good quality are required. The celebrated Olivier de Serres ſays on this ſubject, that, "by a public decree, dunging is forbidden at Gaillac for fear of leſſening the reputation of the white wines, with which the people of that diſtrict ſupply their neighbours of Toulouſe, Montauban, Caſtres, and other places, and of thus depriving them of the great profit thence ariſing, which forms the beſt part of their revenue."

There are ſome individuals, however, who, in order to have a more abundant crop, dung their vines; but they thus ſacrifice the quality to quantity.

The dung moſt favourable to the vine is that of pigeons or poultry; dung fœtid or too putrid is carefully rejected, as it has been proved by obſervation that the wine often contracts from it a very diſagreeable taſte.

In the iſles of Rhé and Oleron the vines are dunged with ſea-weed (*fucus*); but the wine thence acquires a bad quality, and retains the peculiar odour of that plant. Chaſſeron has obſerved, that the ſame plant decompoſed into mould manures the vine with advantage, and increaſes the quantity of the wine without hurting the quality. Experience has alſo taught him that the aſhes of ſea-weed form excellent manure for the vine. This able agriculturiſt is of opinion that vegetable manure is not attended with the ſame inconveniences as animal manure; but he thinks, and with juſtice, that the former cannot be uſed with advantage except when employed in the ſtate of mould.

The method of cultivating vines on poles or props ought to be commanded by the climate. This method belongs to cold countries, where the vine has need of the whole heat of the ſun, naturally weak. By raiſing them, therefore, on poles placed perpendicular to the ground, the earth, being uncovered, receives all the activity of the rays, and the whole ſurface of the plant is completely expoſed to their action. Another advantage of cultivating on props is, that it allows the vines to be placed nearer to each other, and that the produce is multiplied on equal ſurfaces. But in warmer climates the earth requires to be ſheltered from the exceſſive heat of the ſun; the grapes themſelves have need of being protected from its ſcorching rays, and to accompliſh this view the vines are ſuffered to creep on the ground; they then every where form a covering ſufficiently thick and cloſe to defend the earth, and a great part of the grapes, from the direct action of the ſun. But when the increaſe of the grapes has attained to its maximum, and nothing is neceſſary but to bring them to maturity, the cultivators collect in bundles the different branches of the vine, uncover the grapes, and by theſe means

facilitate

facilitate the maturation. In this case they really produce the same effect as is produced by propping; but recourse is had to this method only when the grapes are too abundant, or when the vines grow in soil too fat or humid. In some countries the vines are stripped of their leaves, which produces nearly the same effect; in others, the pedicle of the grapes is twisted to determine the maturity by checking the vegetation. The antients, according to Pliny, prepared their sweet wines in this manner: *Ut dulcia præterea fierent, asservabant uvas diutiùs in vite, pediculo intorto.*

The method of pruning the vines has also a great influence on the nature of the wine. The greater the number of branches left to one vine, the more abundant the grapes, but the worse is the quality of the wine.

The art of cultivating the vine, and the method of planting it, have a powerful influence on the quality and quantity of the wine. To show the effect which cultivation has on the vine, it will be sufficient to observe what takes place in regard to vines left to themselves; it will be found that the soil, soon covered with foreign plants, acquires firmness, and is afterwards but imperfectly accessible to the air and to water. The vine, being no longer pruned, sends forth weak shoots, and produces grapes which decrease in size year after year, and which scarcely ever come to maturity. It is no longer that vigorous plant the annual vegetation of which covered the soil to a great distance. The grapes are no more that well-nourished fruit which afforded sound and saccharine aliment; the vine becomes stunted, and its fruit, of a bad and weak quality, attests the languid and ruinous state of the soil. By what are these changes produced? By the want of cultivation.

We may therefore consider the good state of the soil as the work of nature: all the art consists in stirring it, turning it up several times, and at favourable periods. By these means it is freed from all noxious plants, and it is better prepared for receiving water, and for transmitting it with more ease to the plant; the air also can penetrate to it with more ease, and thus all those conditions necessary for proper vegetation are united. But when, on account of ſome particular ſpeculations, it is neceſſary to obtain wine in greater abundance, and when the quality may be ſacrificed to this conſideration, the vines in that caſe may be dunged, more ſhoots may be allowed to the ſtems, and all the cauſes which can multiply the grapes may be united.

## II. *Of the Time moſt favourable for the Vintage, and the Proceſſes employed during that Period.*

Olivier de Serres obſerves, with great juſtice, that if the management of the vine requires great ſkill and intelligence, it is at the period of the vintage that theſe things are neceſſary, to obtain in perfection and abundance the fruits which Providence thence diſtributes to us. Every body allows that the moment moſt favourable for the vintage is that when the grapes come to maturity; but this maturity can be known only by the union of the following ſigns:

1ſt, The green ſtalk of the grapes turns brown.

2d, The grapes become pendulous.

3d, The ſtones of the grapes loſe their hardneſs; the pellicle becomes thin and tranſparent, as is obſerved by Olivier de Serres.

4th, The cluſters and grapes can be eaſily detached from the twigs.

5th, The juice of the grapes is ſavoury, ſweet, thick, and viſcid.

6th, The ſtones of the grapes are free from any glutinous ſubſtance, according to the obſervation of Olivier de Serres.

The fall of the leaves announces rather the return of winter than the maturity of the grapes; this ſign, therefore, is conſidered as very uncertain, as well as putridity, which a thouſand cauſes may occaſion, none of them ſufficient to enable us to deduce from them a proof of maturity. When the froſt, however, makes the leaves to fall, the vintage ought not to be longer deferred, becauſe the grapes are then ſuſceptible of no further maturity. Their remaining on the vine could tend only to promote putrefaction.

"In 1769, the grapes, ſtill green," ſays Rozier, "were ſurpriſed prifed by the froft on the 7th, 8th, and 9th of October. They gained nothing more by remaining on the vines till the end of the month; and the wine was acid and of a bad colour.

There are fome qualities in wine which cannot be obtained but by fuffering the grapes to dry on the twigs. Thus, at Rivefaltes, and in the iflands of Candia and Cyprus, the grapes are fuffered to remain expofed to the winds before they are cut. The grapes which furnifh tokay are dried; and the fame procefs is employed for fome of the fweet wines of Italy. The wines of Arbois, and of Chateau-Chalons, in Franche-Comté, are produced from grapes which are not cut till towards the end of December; at Condrieu, where the white wine is celebrated, the grapes are not cut till near the middle of November. In Tourraine, and other places, a kind of wine called *vin de paille* is made, by collecting the grapes during dry weather, and when the fun is in full force; they are fpread out, fo as not to touch each other, on hurdles, which are expofed to the fun, and then fhut up when he is fet; the grapes which rot are carefully removed, and when the whole are well dried, the juice is expreffed and made to ferment.

Olivier de Serres fays, it has been proved by experience, that the beft period of the moon for collecting grapes in order that they may keep, is her decreafe rather than her increafe. He, however, allows, that when the grapes are ripe it is better to confult the weather than the moon; and in this we perfectly agree with him.

But there are fome climates where the grapes never come to maturity: fuch are almoft all the northern parts of France; and in that cafe the grapes muft be collected green, that they may not be expofed to rot on the twigs. A moift and rainy autumn muft increafe the bad quality of the juice. All the vineyards in the neighbourhood of Paris are in this fituation; the vintage there is, of courfe, earlier than in the fouth, where the grapes never ceafe to ripen though the heat of the fun continually decreafes.

When the neceffity of commencing the vintage has been afcertained, a great many precautions muft be taken before it is begun. In general, the vintagers ought not to venture to labour but when the foil and the grapes are dry, and until the weather appears fo fettled as to give reafon to believe that their occupations will not be interrupted. Olivier de Serres recommends, not to collect the grapes till the fun has difperfed the dew depofited on them by the coolnefs of the nights: this precept, though generally true, cannot be univerfally applied; for in Champagne the vintagers collect the grapes before funrife, and fufpend their labours towards nine in the morning, unlefs the fogs occafion humidity throughout the whole day: it is only by this care that they obtain white and brifk wines. It is well known in Champagne, that twenty-five cafks of wine are obtained inftead of twenty-four, when the vintagers labour during the continuance of the dew; and twenty-fix during the fog. This procefs is every where ufeful when wines exceedingly white and brifk are required. Except in the above cafes the grapes ought not to be cut until the fun has difperfed all the moifture from their furface.

But fome precautions are neceffary to afcertain the period moft proper for the vintage, and fome muft be obferved in regard to the mode of operation. An intelligent agriculturift will not commit the care of cutting the grapes to inexpert mercenaries: as this part of the labour is not the leaft important, we fhall here give a few obfervations on it.

1ft, A fufficient number of vintagers ought to be engaged that the vat may be filled in one day: this is the only method of obtaining an equal fermentation.

2d, Women on the fpot fhould be preferred; and none ought to be employed but thofe who have become expert in this kind of labour.

3d, The labourers ought to be under the fuperintendance of a ftrict and intelligent overfeer.

4th, They ought to be prohibited from eating the grapes, both to prevent crufts of bread and other food from being mixed with the juice, and to preferve for the prefs the ripeft and moft faccharine grapes.

5th, The tails of the grapes ought to be cut very fhort, and the operation ought to be performed with a pair of good fciffars. In the *Pays de Vaud* the grapes are detached by means of the nail, in Champagne a pruning-knife is employed:

employed: but the two laſt methods are attended with the inconveniency of ſhaking the ſtem.

6th, No grapes ought to be cut but thoſe ſound and ripe: thoſe which are putrid ought to be rejected, and thoſe ſtill green muſt be left on the twigs.

In all places where the cultivators are deſirous to obtain wines of a good quality, the grapes are collected at two or three different times. In general, the firſt vat-full of juice is always the beſt. There are ſome countries, however, where the grapes are almoſt collected without diſtinction, and at one time; the juice is expreſſed without picking, but the wines are very inferior to what they might be, if more care were employed in the operations of the vintage.

When the grapes are to be picked, the following rules may be obſerved: To cut only thoſe cluſters which are beſt expoſed, thoſe the grapes of which are equally large and coloured; to reject all thoſe which have been ſheltered, and near the ground; and to prefer thoſe which have ripened at the bottom of the vines.

In the vineyards which furniſh the different kinds of Bourdeaux wine, the grapes are carefully picked; but the method of picking the red grapes differs from that employed for picking the white: in picking the white, neither the putrid nor the green grapes are collected; in regard to the white, the putrid and the ripeſt are preferred, and the picking is not begun till a great many of the grapes have become putrid. This operation is ſo minute in certain diſtricts, ſuch as Sainte-Croix, Louſſiac, &c. that the vintage there continues two months. In Medoc the operation of picking is performed twice for the red wines; at Lagnon it is performed three or four times; for the white grapes at Sainte-Croix, five or ſix; at Langoiran from two to three; and two in all the Graves.

In ſome countries a vintage compoſed of grapes perfectly ripe is dreaded. The cultivators apprehend that the wine will be too ſweet, and they remedy this inconvenience by a mixture of large grapes leſs ripe. In general, the wine is not briſk and pungent, but when grapes are employed which have

have not acquired perfect maturity. This is what is practised in Champagne and other places.

In some countries where the grapes never come to absolute maturity, and consequently cannot develop that portion of saccharine principle necessary for the formation of alcohol, the cultivators proceed to the vintage before the appearance of the hoar-frosts; because the grapes still possess a sharp principle, which gives a peculiar quality to the wine. It is observed in all those places, that a degree more towards maturity produces wines of very inferior quality.

7. When the grapes are cut they ought to be put into baskets; taking care not to employ any of too large a size, lest the juice should be lost by the superincumbent weight. As it is very difficult, however, to transport the grapes from the vineyard to the vat without altering them by pressure, and consequently without expressing more or less of the juice, baskets ought not to be employed but to receive the grapes as they are cut; and when full they ought to be emptied into boxes or scuttles, that they may be more conveniently conveyed to the vat. They ought to be carried in carts, or on the backs of men, or of mules: which of these three means are to be employed must be determined by local circumstances. Carts are, no doubt, less expensive, though attended with this inconvenience, that the grapes may be injured by the repeated shocks they experience: the motion of a horse is gentler, as well as more regular. Scuttles are employed in all countries where the grapes are not very ripe, and where there is little danger of their being injured by the carriage.

[To be continued.]

## XV. *On the Extraction of Opium from Garden Lettuce.*

THE plant which has hitherto been cultivated for the production of opium is the *papaver somniferum*, or *white poppy*, in the class of polyandria, and order monogynia, of Linnæus. It is an annual plant, from the heads or capsules of which this drug is obtained in Persia, Arabia, and other

warm

warm regions of Aſia, by making in them longitudinal inciſions, from which a milky juice exudes, which, being inſpiſſated, forms the officinal opium.

According to M. Baumé, 4 pounds of common opium conſiſt of

| | ℔. | ℥. | ʒ. |
|---|---|---|---|
| *Inſoluble* matter - - | 1 | 1 | 0 |
| *Extractive* matter - - | 1 | 15 | 0 |
| *Reſin* - - - | 0 | 12 | 0 |
| Volatile concrete *oil* - - | 0 | 3 | 7 |
| *Saline* matter - - - | 0 | 0 | 1 |
| ℔. | 4 | 0 | 0 |

It has been long known that lettuce poſſeſſes narcotic properties; till lately, however, none had extracted from it a ſubſtance poſſeſſing all the properties of opium.

Dr. Coxe, of Philadelphia, has proved (American Philoſophical Tranſactions, vol. iv.) that the inſpiſſated milky juice of the *lactuca ſativa*, or common cultivated lettuce of Linnæus, is *real opium*, and, according to every appearance, of a better quality than the eaſtern; for the principal virtues of this medicine are believed to reſide in the *extractive* matter; and, by comparative experiments, it was found that 10 grains of extractive matter were taken up by two ounces of rain water from 20 grains of lettuce opium; while, from the ſame quantity of common opium, only nine grains were taken up by an equal quantity of the ſame water.

The ten grains of the former which were left on the filter, being affuſed with half an ounce of alcohol, and again filtered on the tenth day after, left on the filter ſeven grains. The quantity of reſinous matter, then, was three grains.

The 11 grains left from the common opium, by a ſimilar treatment, were found alſo to contain three grains; the portion inſoluble either in water or alcohol being eight grains.

The reſin, being afterwards precipitated from the alcohol by the addition of water, that of the lettuce appeared whiter than the other.

By trials made in the Pennſylvania hoſpital, and by experiments made by Dr. Coxe upon himſelf, the lettuce-opium was found to poſſeſs all the properties of the common.

The

The milky juice from which the opium is prepared exists in the stalk and in the leaves of the plant. It is not indiscriminately deposited throughout, but is placed in appropriate vessels running longitudinally in the woody or fibrous part of the stalk. The internal or medullary part of the plant is soft, and perfectly bland to the taste; abounding in a transparent mucilaginous juice, which has not the smallest analogy to the milky one above mentioned. The best time for collecting the milky juice is when the plants are beginning to seed: before this it has not acquired its medical properties, and at a later period the produce is by no means so considerable.

It is procured in the same manner as from the poppy, *viz.* by incisions; with this difference, that in the poppy they are longitudinal, but in the lettuce they must be circular. A very moderate depth suffices. It exudes freely in milky drops, which may be either immediately collected, or suffered to dry on the stalk, and then scraped off and deposited in proper vessels.

Some attempts were made to obtain it by pressure, but the other juices of the plant seemed to alter it considerably.

All the species of lettuce contain opium in a larger or smaller proportion. The common lettuce, as has before been observed, produced that made use of by Dr. Coxe; but the *lactuca sylvestris* or *virosa* of Linnæus contains it most abundantly. The former, however, should perhaps be preferred: it will serve the double purpose of cultivating for the table as well as for the druggist. The sale of the supernumerary plants would probably more than repay the expense attending the cultivation of those intended for opium: indeed, a number of plants generally run to seed and are lost, at present, which might, and we hope in future will, be made to turn to good account.

It is a curious circumstance, that while Dr. Coxe was engaged on this interesting business in America, Mr. Cartwright (to whom the world is indebted for the discovery of the efficacy of yeast in curing putrid fevers) was engaged in similar experiments in England. The arrival of the fourth volume of the American Transactions in this country, and from which we have extracted the preceding remarks, has, however, anticipated his intention of making the fact public, that as good opium may be obtained from lettuce as any that is imported.

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XVI. *Account of* C. F. DAMBERGER'S *Travels through the interior Parts of Africa, from the Cape of Good Hope to Morocco.*

[Concluded from p. 78.]

THE kingdom of Haoussa our traveller describes as the most beautiful country he had seen since his departure from the Cape. On the east it is bounded by the kingdom of Mophaty (Zansara), on the north by Fomingo, on the west by Feene, and the south by the kingdom of Bahara. The river Niger, which intersects a part of this country, renders it fruitful, and conduces greatly to facilitate its commercial intercourse; for a great many small vessels go from Tambuktoo to Boosu, where the goods are unloaded and conveyed to the more distant parts of the country by caravans. The land is fruitful, and if well cultivated would be exceedingly productive. It abounds with animals of every kind, and is well supplied with timber and various sorts of fruit: in the mountains are found salt and saltpetre, and in the forests honey and wax. The greater part of the inhabitants wear long dresses of coloured cotton cloth fastened round their bodies, and instead of shoes have leather thongs tied crosswise over their feet: on the head they generally wear a piece of coloured cotton or woollen cloth. The city of Haoussa is one of the largest in Africa. According to Damberger it is half a day's journey in length and two miles in breadth.

During the course of his military expedition our traveller endeavoured to secure the friendship of some Moors, and to obtain from them information respecting his future journey, as he had resolved to effect his escape the first favourable opportunity. With this view, and to make himself better acquainted with the route, he obtained permission from the king to repair frequently to the suburbs and neighbouring country; but on these occasions he was always accompanied

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by a Moor, who had orders from the king to watch his motions. Finding it difficult, therefore, to put his defign in execution, he refolved to purfue another plan: he went no more abroad, but remained at home, pretending to be fick. The officer who had the care of the Moors having inquired, the fecond day after, what was the matter with him, he replied, that he apprehended being attacked by a fever. When this was told to the king, his majefty confulted one of the priefts in what manner Damberger could be cured; and the prieft, much to our traveller's fatisfaction, replied, that it would be neceffary for him to bathe feveral times a day. In confequence of this prefcription he was ordered by the king to bathe in a fmall lake before the city under the care of a Moor. This he did for eight days without any hope of being able to effect his efcape; but on the ninth day, after going out, he pretended to be exceedingly weak, and faid he had obtained leave on that account to remain abroad till the evening. His attendant, believing that he fpoke the truth, informed him that he would in the mean time go back to the town, and return for him in the evening. Scarcely, however, was the Moor out of fight, when our traveller fet off as faft as he could, taking the road to the capital of Feene, at which he arrived on the 20th of September, and where he remained fome months.

This city is fituated on a barren eminence, which in the rainy feafon, that is to fay, in the months of June and July, is fo entirely furrounded with water that it is impoffible to walk from it the diftance of half a mile. Thofe whofe bufinefs or occupations render it neceffary for them to proceed further, muft employ camels or horfes; but the water is fo deep that they are often in danger of being drowned. The city, which is well built according to the African mode, is about two miles in circumference. It contains four principal ftreets, which crofs each other, forming at the place of their interfection a market; where there are expofed for fale, not only the productions of Africa, but European articles, brought thither by caravans, fuch as looking-glaffes, buttons, needles, toys, &c. which are fold chiefly for money or bullion. The caftle lies on the weft, and is furrounded by a wall, which on one fide is is connected with the walls of the town. These walls are constructed of common stones and flints; but the houses, which are sometimes two stories high, are built, for the most part, of straw, leaves, timber, and clay. The town is divided into two parts; one, consisting of houses called *Konko borroh jamgala*, or the hill of the free town, is inhabited by the merchants, priests, and magistrates; the other part, called *Iliny dabo konko*, the hill of the black land, received this appellation, in all probability, because the huts it contains, and which are inhabited chiefly by Arabs and indigent Moors, stand in a place where the soil is a kind of black earth. Besides eighty public temples and mosques, there are here a great many private temples in the houses of the principal inhabitants. Damberger found here what he had not seen for a long time, *viz.* four public wells: each of them was walled round in a neat manner with flints, and had a winding stair that conducted down to the water. They were not supplied with water from springs, but by the rain which fell in the rainy season; at other times water was conducted to them by conduits from the Niger. They were under the inspection of persons appointed to take care of them, and who had servants whose business was to open and shut them; for they were always kept shut during the night. According to Damberger, the people here, in cases of fire, do not employ water to extinguish it, but in its stead use sand. The king resides here only four months in the year; the remaining part of it he spends at Sille, or in some other town, and sometimes also in camp. The Arabs employ themselves in agriculture, and though the ground is covered with sand they obtain good crops; for the land is fertilised partly by the inundation during the rainy season, and partly by manure.

Our traveller left this place on the 7th of April, and arrived at Nahga, from which he proceeded up the Niger in a boat, and on the 11th reached Sille or Silla, the second residence of the king of Feene. It is situated close to the Niger, and is larger than Feene, but not so well built. It has two principal streets with a cross street, and consists of houses and huts scattered here and there in an irregular manner. A canal from the Niger passes along the cross street for the purpofe of fupplying the town with water. There are only about a hundred ftone houfes in the town, becaufe the ftones muft be brought from a great diftance; but the number of the huts is confiderable. They are built of the trunks of the palm tree, and covered with palm leaves. The mofques and temples, which amount to about a hundred, are conftructed of palm branches interwoven with each other, and are covered in the fame manner as the huts.

After leaving Sille, our traveller fet out with a caravan, and paffing Muta, Saatata, and Sanoho, or the Gold Mountains, reached the confines of the kingdom of Nytokka. Here the caravan refted a day, and then croffing the Gatta Mahara, or Defert of Lions, which is fix days journey in length, arrived among a people called the Seegmartons, who refide in holes and caverns of the mountains. Thefe people have neither king nor ruler, but live in a ftate of unreftrained freedom, and form excellent foldiers, who, on the breaking out of a war, are taken into pay by fome of the neighbouring nations.

On the 24th of May the caravan afcended a large chain of mountains, and, continuing their journey through a fandy defert, arrived on the 1ft of June at a village of the kingdom of Watometh, where they halted. On the 5th of June they afcended another chain of mountains, croffed the Sampi river by fwimming, but were expofed to great danger on account of its being at that time much fwollen, and, paffing fome fandy plains, reached the boundaries of the kingdom of Tamohata. Here they were attacked by a horde of Arabs, and loft two men and a camel; but they efcaped without further lofs, and arrived at the mountains which form the boundaries of the large defert of Sahara.

After this our traveller fell fick near a place called Euyfach, and, being left behind by the caravan, remained in the next village, under the care of a Jew, until he recovered. He then proceeded on horfeback, accompanied by fome Moors, to Tegorarin, where the Moors fold him to a flave-merchant, for whom he made various articles of furniture, and who carried him, along with four young female flaves, to Omozab, and refold him to a Moffelemi. He, however, did not

long

long remain with his new maſter; for he was again ſold to an inhabitant of Mozzabeth, who in four months ſold him to a merchant of Morocco, who carried him to that city.

After living for ſome time with this maſter, who, inſtead of treating him as a ſlave, behaved to him with great kindneſs, he was redeemed by a private agent of the French Republic, and, taking his paſſage on board a Dutch ſhip bound to Holland, arrived in the Texel on the 9th of February 1797.

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XVII. *Notice reſpecting the Inſcriptions brought from Egypt by the Officers of the French Army. Read in the public Sitting of the National Inſtitute on the 5th of January. By* C. AMEILHON.

THE valuable monument which contains theſe inſcriptions was found near Roſetta in Egypt *. Exact impreſſions of them were taken from the ſtone itſelf by a particular proceſs, invented by Marcel and Galland, the former director, and the latter corrector, of the national printing-office eſtabliſhed at Cairo: and theſe impreſſions were tranſmitted to the National Inſtitute at Paris, who entruſted them to me that I might firſt examine the Greek inſcription. The firſt of theſe inſcriptions is in the hieroglyphical or ſacred characters; the ſecond in the characters of the language of the country, that is to ſay, the language ſpoken at that period by the vulgar in Egypt; and the third in the Greek characters. The laſt informs us that they all contain one decree expreſſed in three languages.

It was no doubt to ſecure to this monument an unalterable exiſtence that the authors of the decree declared that it ſhould be engraven on one of thoſe ſtones diſtinguiſhed by their hardneſs; which agrees with the report of general Dugua, who certifies that the ſtone is a granite. This wiſe precaution has not, however, been attended with complete ſucceſs: Time, which devours every thing, has corroded the ſtone in ſeveral places, ſo that none of the inſcriptions are entire.

The inſcription in hieroglyphical characters, the knowledge

* See the Philoſophical Magazine, Vol. VIII. p. 94.

of

of which is the most interesting, is mutilated in every part; and what remains of it is not above half what it ought to be.

The inscription in the vulgar language of the country, which deserves also to engage the attention of learned orientalists, is the least effaced.

The Greek inscription has suffered much more than the preceding. Of the fifty-four lines it contains, twenty-four have been more or less altered: some of them have lost above a fourth of their length, which disfigures the text so as to render it sometimes altogether unintelligible.

But, however defective this inscription may be, we will venture to assert that there is nothing hazardous in what we are going to say respecting it.

This inscription attests that it was a monument erected in honour of Ptolemy Epiphanes, the son of Ptolemy Philopater and Arsinoë, Ptolemy Epiphanes was the fifth of the fourteen sovereigns who reigned over Egypt after the death of Alexander, from Ptolemy the son of Lagus, surnamed *Soter*, or the saviour, to the famous Cleopatra. This monument was erected in consequence of a decree issued by the authority of the priests, who had assembled at Memphis from all the districts of Egypt to celebrate the inauguration of the new king, the son of Ptolemy-Epiphanes. The name of the Ptolemy who is the object of the inscription is scarcely ever repeated in it without being accompanied with the epithets *always-living* or *immortal*, the *beloved son of the god Ptha* or Vulcan, the *god Epiphanes, most gracious*. He is there compared to Vulcan, the great Hermes, Orus the son of Isis and Osiris. His father, his grandfather, and the other Ptolemys his ancestors participate with him in the honours of this pompous preamble; after which comes the first part of the decree.

The priests explain there the motives on which it is founded. These motives, in general, are the piety of the prince towards the gods and his beneficence towards men. The inscription says that Ptolemy Epiphanes had given to the temples, and the priests who served in them, large donations in money, and corn, and other largesses of every kind; that by the force of his arms he had restored tranquillity to Egypt;

Egypt; that he had afterwards endeavoured to repair the evils occaſioned by war, and to make the people comfortable by remitting, either entirely or in part, the taxes that were due, or by diminiſhing the burthen of thoſe which had been eſtabliſhed in the courſe of his reign. The inſcription adds that he had cauſed the priſons to be opened to thoſe detained in them, and had diſcharged a great number of accuſed perſons who for a long time had been waiting for their ſentence; that he had ordered that all the rents which conſtituted the domains of the temples, and all thoſe which under the reign of his father Ptolemy Philopater had been raiſed annually, either in money or in kind, from the vineyards and gardens, for the behoof of the gods, ſhould continue to be punctually paid as before; and that the prieſts ſhould not pay more for their perſonal taxes than what they had been accuſtomed to pay from the beginning of his father's reign.

This inſcription here calls to remembrance a particular fact, which is worthy of notice. It informs us that there were manufactories of linen cloth denoted under the name of *byſſus*, depending on the temples, and that a certain quantity of this merchandiſe was collected every year for the uſe of the navy and for the particular ſervice of the prince; that Ptolemy Epiphanes on a certain occaſion remitted a part of this tax, and that on another he ſuſpended the levying of it. This prince alſo eſtabliſhed, in favour of the people and their religious worſhip, various ordinances, into the particulars of which we cannot enter without tranſgreſſing the limits allowed for this extract.

In the eighth year of the reign of Ptolemy Epiphanes there was a great inundation of the Nile. This prince cauſed dykes to be conſtructed to confine the river to its bed, and to prevent it from overflowing the plains, which it was accuſtomed to do almoſt every year. The inſcription ſpeaks alſo of the ſiege and capture of Lycopolis (the city of the wolves), which this prince carried by aſſault. The inſcription is here ſupported by hiſtory, from which we learn that Lycopolis actually revolted againſt Ptolemy Epiphanes, and that after entering it as a conqueror he treated the inhabitants with great ſeverity. But if he puniſhed with the utmoſt rigour the rebels who perſiſted

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in their revolt, he generously pardoned those who returned to their duty; he was even desirous that their property should be restored to them.

The ox Apis and the ox Mnevis, the two chief deities of the religion of the antient Egyptians, participated also in these acts of pious liberality. "Carrying his foresight further than any of his predecessors," says the inscription, "he assigned considerable funds for defraying the expense of their funerals and interment, for supporting their worship and maintaining their temples. The gods therefore," continues the inscription, "to reward these noble actions, conferred on him health, strength, victory, and all those advantages which can render a sovereign happy."

The priests then proceed to the decree. This second part of the inscription is unfortunately that which has suffered most from the injury of time. It may however be clearly seen, beyond all manner of doubt, that it is there said that all the temples which had been before constructed in honour of Ptolemy Epiphanes, and the other four Ptolemys his predecessors, were to be greatly enlarged and embellished; that in each of these temples a statue should be erected to Ptolemy Epiphanes, to be called the statue of *Ptolemy the defender of Egypt*; that before it should be placed the principal divinity of the temple presenting to him the attributes or trophies of victory; that the priests should perform their service near these images three times a day; and that there should be deposited in the sanctuary of the temples a small statue of the new god inclosed in a small temple or shrine; that the small temple and statue should be carried like those of the other gods during those grand solemnities, when it was customary to take them from the temples to bear them in public procession, on which account these solemnities were called *Exodia*, or issuing from the temples.

Notwithstanding the ruin of this part of the inscription, and the disorganisation of the text, which increases as we advance, we can discover that it contains certain details respecting the worship of the new deity. Allusion is made in particular to a grand festival, which was to commence at the neomenia of the month Thouth, and to continue five days, during which the priefts were to appear with crowns on their heads.

In regard to the date of this curious monument, it may be fixed, without much fear of being miftaken, at the year 186 before the Chriftian æra. Ptolemy Epiphanes, indeed, having died, according to the beft chronologifts, in the year 177 before the common æra, it follows, that the inauguration of his fon, which took place nine years after, muft be referred to the year 186. But the infcription and inauguration of Ptolemy Philometor, the fon of Ptolemy Epiphanes, are of the fame epoch as the infcription attefts.

We fhall not here attempt to fupply what is wanting in the text of the infcription. This attempt would be ufelefs and rafh; *ufelefs*, becaufe the fecond infcription, which is in the antient language of the country, and the third, *viz.* the Greek infcription, muft reciprocally fupply what has been loft; *rafh*, fince in the latter cafe it might happen that the reftitutions made in the Greek infcription by that which precedes it, might formally contradict the fupplementary additions of the commentator.

It muft however be acknowledged, that I have not carried my fcruples fo far as not to venture to finifh a word begun, or not to terminate a phrafe, the fenfe of which might be doubtful when the words preferved neceffarily fuggefted thofe which had difappeared. I have not even abftained from making fome conjectures refpecting certain parts of the infcription where the text was fo much deftroyed that the leaft trace of it did not remain.

This firft labour on the Greek infcription of Ptolemy Epiphanes may be of fome utility to thofe who are to exercife their talents on the fecond, in order to proceed afterwards to the explanation of the firft. But it muft be confeffed that the ftate of thefe three infcriptions, and that in particular of the hieroglyphical characters, gives reafon to think that great difficulties muft be overcome, and great efforts made, to accomplifh the propofed end.

## XVIII. *Researches respecting the Laws of Affinity.* By C. Berthollet, *Member of the National Institute, &c.*

CHEMISTS have long been looking for Berthollet's work on this subject, which has at last made its appearance, and contains much new and useful matter. A mere analysis of the work would be of little use to our readers; we shall therefore present extracts of such parts as may tend to make them acquainted with the nature of the facts on which he founds his theory, and which deserve the attention of every chemist.

Berthollet divides his memoir into fifteen articles.

I. In the first, after an eulogy on Bergman, he states his intention to be, "to prove that elective affinities do not act like absolute forces, by which one substance in a combination would be displaced by another; but that, in all the compositions and decompositions which are produced by elective affinity, there is a distribution of the combined substance among those which exercise contrary affinities; and the proportions of this distribution are determined not only by the energy of the affinity of these substances, but also by the quantity with which they act; so that quantity can make up for the force of affinity, in order to produce the same degree of saturation.

"If I establish," adds the author, "that the quantity of a substance can make up for the force of its affinity, the result will be, that its action is in proportion to the quantity necessary to produce a determinate degree of saturation. I give the name of *mass* to that quantity which is the measure of the capacity of the saturation of the different substances. In comparing, therefore, the affinities of substances, I shall pay attention to the ponderable quantities, which in this comparison ought to be equal; but in comparing their action, which is composed of their affinity and their proportion, it is their mass that ought to be considered."

The author then announces, that in the following discussions he will chiefly employ "acids and alkalies, (comprehending among the latter those earths which have the same

4 action,)

action,) becaufe they act with a force fo great as to make the influence of little caufes difappear; becaufe they often produce comparable degrees of faturation; and becaufe they give refults eafy to be obferved." But the confequences which Berthollet draws from their properties he applies to all combinations; and feveral examples are adduced to prove that the principle which he eftablifhes extends to every chemical action of bodies.

After having proved, by direct experiments, that the chemical action of bodies, the forces of which are contrary, depends not only on their affinity but alfo on their quantity, the author announces, that he means to felect obfervations refpecting the different kinds of combinations, which will confirm this principle, and which will prove its extent. "I fhall then examine," fays he, "the circumftances by which it is modified, or the affections of bodies which favour or leffen their chemical action, and which occafion a variety of proportions in the combinations they can form. I fhall apply thefe confiderations to complex affinities and to thofe of compound bodies; and, in the laft place, I fhall endeavour to fix the bafis on which the general and particular theories of chemical phænomena depend.

II. *Experiments which prove that in Elective Affinities the Subftances which exercife oppofite Affinities divide themfelves in that which is the Subject of the Combination.*

To demonftrate the truth of this principle, C. Berthollet defcribes feveral experiments, of which we fhall mention the following: "I kept in a ftate of ebullition," fays he, "in a fmall quantity of water, an equal weight of potafh, purified by alcohol, and of fulphat of barytes. The operation was performed in a retort, and, confequently, without the contact of the air: the mixture was reduced to a ftate of drynefs, and the refiduum being treated with alcohol, which diffolved the potafh, and after that with water, the latter effected a folution which ftill exhibited alkaline properties. The alkali was faturated with acetous acid, after which there was formed, by evaporation, a pretty confiderable quantity of fmall cryftals, which had all the characters of fulphat of potafh; fo that *the sulphat of barytes was in part decomposed,* and *the sulphuric acid was divided between the two bases.*

"The other experiments were made, 1st, with sulphat of potash and lime; 2d, oxalat of lime and potash; 3d, oxalat of lime and nitric acid: 4th, phosphat of lime and potash: 5th, potash and carbonat of lime: 6th, soda and sulphat of potash.

"In all these experiments *the bases,* which pass to form with acids the strongest and firmest combinations, *are* seen in part *eliminated by a base to which a weaker affinity is ascribed,* so that *the acid is divided between two bases. Acids are* seen also *eliminated* in part *from their base by others,* the affinity of which is considered as inferior, so that *the base is divided between two acids.*"

The author observes, that "if only a small quantity of the decomposing substance be employed, the effect will not be sensible;" and concludes, that "when a substance acts on a combination, that which is the subject of the combination divides itself between two other substances, not only according to the respective energy of their affinity, but also according to their quantity."

### III. *Observations which confirm the Principle, that Chemical Action is in the Ratio of the Mass.*

The author makes observations on the different kinds of combinations exposed to elective affinity, and examines whether the principle, that chemical action is in the ratio of the mass, cannot be exactly applied to explain them.

"If carbonat of potash," says he, "be treated with lime, the whole of the carbonic acid cannot be taken from the potash even by performing successive operations with more lime; and, if the liquid be evaporated, the residuum still effervesces when saturated with acids—because the potash which remains present with the lime opposes its action; and the more carbonic acid the lime has taken up, the more powerful the potash becomes to defend its own combination with the carbonic acid;" or, in other words, to resist decomposition.

"When an equilibrium is established between the action of the lime and the resistance of the potash, if the liquor be filtered

filtered and evaporated, the alkaline part, which is superabundant to the conſtitution of the carbonat of potaſh, that is to ſay, all the portion not defended by a ſufficiently large maſs of carbonic acid, may be taken away by a weak affinity. Alcohol has this property: by its means a ſeparation may be effected; the *carbonat of potaſh* remains in ſolution in a little water, while *the alcohol of the potaſh* is ſupernatant. The carbonat of potaſh which is ſeparated might be treated alſo with lime, and by this ſecond operation be reduced to a quantity which might be neglected."

C. Berthollet quotes alſo other experiments reſpecting chemical action being in the ratio of the maſs.

" If a carbonat with exceſs of potaſh be treated with alcohol, a part only of its exceſs of potaſh is taken from it.

" The other neutral ſalts have alſo the property of retaining a part of the potaſh when the latter is in exceſs.

" It is known alſo that the phoſphat of lime cannot be *entirely* decompoſed by the ſulphuric acid, though the latter is ranked as having a ſtronger affinity for lime than the phoſphoric acid has.

" The caſe is the ſame when ſulphat of alumine is decompoſed by ammonia: the precipitate always contains ſulphuric acid.

" If magneſia be precipitated from its ſulphat by potaſh, the magneſia retains alſo ſulphuric acid; for, when the magneſia is urged by heat, it has afterwards a pretty ſtrong ſavour of ſulphat.

" All theſe experiments prove that, in chemical analyſis, chemiſts fall into an error when they take for the real weight, either of the alumine or of the magneſia which may be found in the compound ſubſtance, that of the precipitate formed by an elective affinity.

" It reſults from the preceding obſervations, and many others which might be quoted, that in elective affinity the ſubject of the combination divides itſelf between two ſubſtances, which act on it in the ratio of the forces which they may oppoſe to each other.

" One circumſtance which merits attention, and which particularly proves that chemical action depends as much on the

the quantities as on the affinities of the ſubſtances, is, that it is ſufficient to vary the quantities to obtain oppoſite reſults."

IV. *Of the Modifications of the Chemical Action which ariſe from the Inſolubility of Subſtances.*

The author ſucceſſively examined the affections of bodies which may diſguiſe or alter the modifications of the principle eſtabliſhed in the preceding articles. He proves, by a number of experiments, 1ſt, The manner in which an inſoluble ſubſtance acts when oppoſed to a combination: 2d, If a ſubſtance has any ſolubility, its action is compoſed of that of the part diſſolved and of that which retains its ſolidity: 3d, That if an inſoluble combination be attacked by a liquid ſubſtance, the inconveniences of inſolubility ſoon diſappear, when it is ſufficient that the inſoluble ſubſtance ſhould loſe a part of its conſtituent principles to become liquid.

The author then proceeds to the examination of the difference of the ſpecific gravity between the inſoluble and liquid ſubſtance. According to him, it has an influence on their reſpective action, even when agitation and heat are employed, becauſe it continually tends to ſeparate the inſoluble ſubſtance, and to withdraw it from the force oppoſed to it: thus there is a difference in this reſpect between the ſulphat of barytes and alumine.

In the laſt place, if inſolubility prevents the proportions which ought to reſult from the oppoſite forces from being eſtabliſhed, it occaſions ſlowneſs in thoſe which can be eſtabliſhed; and it may eaſily give riſe to deception by the appearances which it produces at the commencement of an operation, ſuch as when concentrated ſulphuric acid is mixed with a ſolution of potaſh, or any other ſalt that requires a large portion of water to diſſolve it: the acid immediately combines with the water, and the ſalt, which loſes its liquidity, is precipitated; but, by prolonging the operation and multiplying the contact, the ſalt diſſolves, and enters into combination with the liquid.

V. *Of Coheſion and Cryſtalliſation.*

The coheſion of the moleculæ of a body is owing to the reciprocal affinity of theſe moleculæ; it is a force which muſt be be surmounted by the action of the substance that tends to combine with these parts, or to decompose their combination. It is well known that argil, the parts of which, by deficcation, have acquired a strong adhesion, is no longer attacked by an acid which has the property of dissolving it when it is in another state.

It is this reciprocal affinity, also, of the saline parts that produces crystallisation, and the latter in chemical action has effects which deserve attention. On this subject the author presents some considerations, as well as on the force produced by crystallisation in a saline solution. "It establishes," says he, "a boundary to the degree of the saturation with a salt to which the water can attain; so that, if it does not dissolve a larger quantity, it is not because its affinity for it is satisfied, but because it has no longer sufficient power to overcome the resistance of the crystallisation." From these and other considerations Berthollet concludes, that the force of cohesion, which had been considered only as an obstacle to solution, determines the quantities of the substances which can be put in action in a liquid, and thereby modifies the conditions of the chemical action: it is that also which causes those separations that take place either by crystallisation or precipitation, and which establishes the proportions of the combinations which are formed in separating from the liquid when the property of being insoluble depends on these proportions.

### VI. *Of the Elasticity of those Substances which exercise a Chemical Action.*

When a substance escapes in the form of gas, in proportion as it is disengaged from an intimate combination, the whole portion which assumes the elastic state does not contribute to the resistance; so that this substance no longer acts according to its mass: the substance opposed to it may then render the decomposition complete, and it will be sufficient to employ the quantity which would have been necessary to form immediately the combination into which it ought to enter, or, at least, a small excess only will be required. "This is what happens," says Berthollet, "in regard to carbonic acid when it forms a carbonat, and when another acid is opposed to it;

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the latter, which acts according to its mass, even if it should have an affinity inferior to that of the carbonic acid, may successively expel it from the combination until no more of it remains, provided it be employed in a quantity somewhat superior to that which would be necessary to form its combination immediately with the base.

It results from all the facts exhibited by the author, that elasticity produces effects analogous to those of the force of cohesion, by modifying, in a contrary manner, the effects of the affinity proper to each substance.

### VII. *Of the Action of Caloric.*

Under this head Berthollet examines the action of caloric on bodies, and the phænomena it produces in the different combinations or decompositions. He also gives a great many experiments on efflorescence and on solvents.

What the author understands by efflorescence is the property which a substance has of rising above the mass, and of thereby separating itself from the chemical action.

"To make soda," says he, "to rise by efflorescence it must be combined with carbonic acid, which it is able to take up from the atmosphere; but the action of carbonic acid, furnished in very small quantity, and in an elastic state, cannot add sensibly to the force that produces the separation of the soda from the combination in which it exists; it only withdraws the eliminated portion, and prevents it from continuing to act on the combination."

In regard to the employment of solvents, the author establishes as a principle, that the object is to overcome the resistance arising from the cohesion of the parts required to be put in action, or from their elasticity, and to multiply their natural contact.

Solvents act on the substances they dissolve, by their affinity and by their quantity, as do all the substances which tend to combine, and every thing that belongs to combination must be applied to them: the author, for an example, takes water, which is oftenest employed as a solvent. Berthollet then examines those circumstances in which this action can sensibly change or modify the results. This leads him to present

present a series of experiments, according to which he establishes his theory; and he concludes with some observations on caloric. "It acts," says the author, "on bodies not equally dilatable, in a manner analogous to solvents, by combating the force of cohesion, and thereby putting the parts in a state to exercise their reciprocal action. Its action concurs with that of the solvents to oppose the force of cohesion; and hence it happens that the solution of a salt by water varies according to the degrees of temperature. When caloric acts on bodies unequally dilatable, it produces separations and new combinations independently of the affinity peculiar to these substances, in the same manner as solvents when acting on bodies unequally soluble.

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## XIX. *On Mr.* WEDGWOOD'S *Pyrometer.*

AS the construction and use of this valuable instrument, the only one yet invented which can convey to the mind any accurate ideas respecting high degrees of heat, and enable us to compare them with each other and with lower degrees, is very generally known, a long description of it would be superfluous. We shall therefore briefly observe, that its indications are obtained from the property which all clays possess, of shrinking or being diminished in bulk by exposure to heat; that, consequently, any piece fitted into a tapering gauge (for instance, a sector opened a little,) will, after exposure to a sufficient degree of heat, pass further into the gauge; and that, the greater the degree of heat it has experienced, the greater will be its diminution of volume, and the deeper will it go into the gauge. Different divisions marked on the side of the gauge will, of course, give the comparative degrees of heat, to which pieces of the same clay, size, and form, may have been exposed. Mr. Wedgwood's gauge consists of two rulers or flat pieces, a quarter of an inch thick and 24 inches long, fixed upon a smooth flat plate, 5-10ths of an inch asunder at one end and 3-10ths at the other, so that they include between them a long converging canal or groove; and the rule which forms one of the sides of this groove is divided

 into

into inches and tenths. The pyrometer pieces are made of a particular kind of Cornish clay by means of moulds, and are pared afterwards, when dry, by a paring-gauge, to insure their being all of one size as to length: a variation in the other dimensions is of no consequence, as it is by the length their shrinkage is to be afterwards measured.

By means of a similar gauge, but by employing the expansion of a piece of silver by heat, Mr. Wedgwood succeeded in obtaining a knowledge of the intermediate degrees of heat between that of boiling mercury and the zero of his own scale; from which he ascertained, that one degree of his was equal to 130° of Fahrenheit's scale, and that the zero of his corresponded to 1077½ F. Consequently, to accommodate the results obtained by the pyrometer to Fahrenheit's scale, all that is necessary is to multiply the pyrometric degrees by 130, and to the product to add 1077½.

It is pretty generally believed that the pyrometer pieces which have of late been prepared, do not give the same results with those which were first made by Mr. Wedgwood; a circumstance which makes it extremely desirable that the quantities and kinds of earth, necessary to form such rolls as will always give correct results, should be accurately ascertained.

From Mr. Wedgwood's own experiments, it appears that the clay he made use of in the construction of his first pieces consisted of two parts of pure siliceous earth to three of argil *.

C. Vauquelin, who has analysed Mr. Wedgwood's pyrometer pieces †, states, that they contain 64·2 parts of pure silex, 25 parts of argil, 6 of lime, 0·2 oxyd of iron, 6·2 of water. These quantities, consequently, with an addition of water to convert the whole into a paste, should serve for making pyrometer pieces equal in powers to those of Mr. Wedgwood.

Whether C. Vauquelin analysed new or old pieces, that he obtained results so different from those of Mr. Wedgwood; whether he be aware that there is any difference between

* *Philosophical Transactions* 1782.

† See *Philosophical Magazine*, Vol. V. p. 290.

them;

them; or whether there be really any difference except what may arife from the force applied in filling the moulds in which the pieces are formed, are points which we cannot determine.

However this may be, C. Gazeran, proceeding on the idea of Vauquelin, has been endeavouring, and with fome fuccefs, to make from the clays found in France (which contain from 30 to 40 *per cent.* of argil) pyrometric rolls applicable to Wedgwood's fcale *. He finds the white clays which contain the largeft proportion of alumine to anfwer beft. That which he made ufe of contained in 100 parts,

| | | |
|---|---|---|
| Argil | - - - | 34·09 |
| Silex | - - - | 41·11 |
| Water | - - - | 19·25 |
| Lime | - - - | 2·30 |
| Oxyd of iron | - - | 0·75 |
| | Lofs | 0·55 |

Of this clay he took 150 parts by weight, which he paffed through a fine fieve; to this he added 63 parts of Fontainebleau fand, wafhed and well triturated, and 200 parts of water. This mixture, having been ftirred once a day for three weeks, was kneaded, for the fpace of two hours, till the pafte was perfectly homogeneous. It was now allowed to dry in the air till it had loft 170 parts out of the 200 of water which had been employed, and then moulded in cylinders made of tinned iron and of a proper fize. The pafte was preffed in the moulds for two hours with the weight of a kilogram (two pounds three ounces). The pieces were then dried in a ftove for 24 hours in a heat of 122° of Fahrenheit, and afterwards adjufted to fit zero of Wedgwood's fcale.

Two of thefe agreeing in weight, within a centigram, with thofe of Wedgwood, having been expofed with two of his to a ftrong heat in a clofe crucible for an hour and a half, Gazeran's indicated the temperature by one of his pieces 159° and by the other 160°, *i. e.* $159\frac{1}{2}$°. Wedgwood's gave 150° and 160, *i. e.* 159°, which is a ftriking coincidence.

C. Gazeran obferves that Mr. Wedgwood's pyrometers have frequently varied 4°, 6°, and 9° from each other, (we

* *Annales de Chimie*, No. 106.

wiſh he had mentioned whether all were taken from the ſame box,) whereas with his own, he ſays, the variations have only been from a half to a whole degree, and they exhibited no ſigns of vitrification when expoſed to a heat able to fuſe iron and deſtroy the beſt Heſſian crucibles.

From his experiments he infers, that, if a clay be employed which contains 34 *per cent.* of argil, and either rock cryſtal, triturated white ſand, or pure ſilex be added to it to make up the proportion before noted, pyrometer pieces may at any time be formed equally refractory with thoſe of Mr. Wedgwood, and whoſe power of contraction will be exactly the ſame as his.

But why ſhould natural clays be made uſe of at all for forming pyrometers, which muſt ſometimes vary in the proportions of their component parts, even when taken from different parts of the ſame bed?

If there be any difference between the Engliſh pyrometers now made and thoſe firſt prepared by Mr. Wedgwood, it moſt probably ariſes from ſome ſuch cauſe; and the ſame difference may be expected to be found in beds of clay in France. It does not ſeem impoſſible that chemiſts every where might agree to employ the ſame proportions of *pure* argil, ſilex, and water, in the formation of pyrometers. Even if the argil were not abſolutely pure, if they employed argil obtained always by the ſame means (as from alum by ammonia, the alum having previouſly undergone ſeveral ſolutions, filtrations, and cryſtalliſations to free it from foreign matters), they would be ſure to form pyrometers which would give ſimilar reſults. Lime and iron ſhould be completely excluded, as ingredients which muſt render the pyrometers leſs refractory.

If, in making pyrometers by ſuch means as we have propoſed, ſuch proportions could be fallen upon as would agree in the reſults with Mr. Wedgwood's firſt-made pyrometers, it would be a great convenience to men of ſcience, as many facts have already been eſtabliſhed by the indications they afforded. If this cannot be done, one of the two following methods might be adopted: Either,

1. To repeat the experiments on the degrees of heat neceſſary

ceſſary to fuſe the different metals, &c. &c. and note them by the reſults obtained from the pyrometers made from *known materials*; noting, at the ſame time, how many degrees of the mercurial thermometer correſpond to one on Wedgwood's ſcale. Or,

2. The object in view might perhaps be more eaſily attained by accommodating the width of the two pieces of braſs in Wedgwood's ſcale to the ſhrinkage of the new pyrometers, in ſuch a manner, that at the wide end, or zero, they might remain as at preſent, and, by making them approach to or recede from each other at the other end, receive the new pieces at that part of the gauge which ſhall indicate the proper degree, obtained by comparing the reſults of ſome experiments made with them and ſome of Mr. Wedgwood's old cylinders, which, though ſcarce, may ſtill be had.

We ſhall make ourſelves, perhaps, better underſtood by aſſuming ſuppoſed reſults to ſhow the kind of alteration that would be neceſſary to accommodate the indications of the new pyrometers which we propoſe, to thoſe which have been determined by Mr. Wedgwood's.

Expoſe one of each to a ſtrong heat in a cloſe crucible. When withdrawn, ſay Mr. Wedgwood's indicates 100°, and that the other would reach 110°. In this caſe the new pyrometer would have ſhrunk more in the ſame degree of heat than the old one; and to make it ſtand at 100°, the true degree by Wedgwood's ſcale, (which we think ought by no means to be altered,) all that would be neceſſary would be to bring the ſides of the gauge ſo much nearer to each other at the narrow end of the groove as to make the new pyrometer piece ſtop at the proper degree. If theſe two pieces were again expoſed, together, to a ſtronger degree of heat, it would be found, that whatever degree Mr. Wedgwood's might indicate in a gauge that had not been altered, the new pyrometer would alſo indicate in the one that had been accommodated to it after the former expoſure to heat.

If the new pieces were found to ſhrink leſs than the old ones, the gauge, of courſe, would require to be proportionally widened at the narrow end, to allow it to reach the degree indicated by Mr. Wedgwood's pyrometer; and in either caſe, the proportion which this difference in the width of the gauge at its narroweſt end might bear to the whole of its preſent width at the ſame end, ſhould be accurately aſcertained to enable chemiſts in different countries to obtain a uniformity in their reſults.

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XX. *An Attempt to prove that the Matter of Heat, like other Subſtances, poſſeſſes not only Volume but Gravity; being a Second Eſſay on Caloric.* By ALEXANDER TILLOCH. *Read before the Aſkeſian Society November* 1800.

IN the haſty eſſay read before this Society in the courſe of our laſt ſeſſion * I ventured to call in queſtion the truth of certain commonly received doctrines reſpecting heat or caloric, mentioned ſeveral facts which admit of concluſions very different from thoſe which have been drawn from them to ſupport the doctrines referred to; and endeavoured to ſhow that heat retains uniformly the ſame character, properties, and mode of action; in oppoſition to thoſe who contend that it is ſometimes *ſenſible* or *free*, and at other times *latent* or *fixed*.

I alſo endeavoured to prove that heat is a real diſtinct ſubſtance, and not a mere quality or accident reſulting from the modification of matter. I ſhowed, by many proofs, that it poſſeſſes volume, which is a characteriſtic of matter; that, when expelled by chemical combinations, the volume of the compound is leſs than the ſum of that of the ingredients; and that, probably, the diminution is exactly equal to the volume of the heat that has been thrown out: that, on the other hand, when the compound is increaſed in volume, it has acquired, from the contiguous bodies, a portion of caloric, probably, exactly equal in volume to that increaſe: and, to be brief, that the general laws enumerated in my former eſſay, and which, I believe, are univerſally admitted, being ſufficient to explain all the known phænomena, without having recourſe to the doctrine of *latent*, as diſtin-

* See *Philoſophical Magazine*, Vol. VIII. p. 70, 119, and 311.

guiſhed

guiſhed from *free heat*, the doctrine ought to be rejected, on the received axiom, that no more cauſes ſhould be admitted in phyſics than what are true, and ſufficient to account for the phænomena.

I alſo ſuggeſted the propriety of philoſophers turning their attention to the determining the maſſes or volumes of heat neceſſary to produce the various effects and changes which that ſubſtance operates upon bodies, inſtead of contenting themſelves with ſpeaking of *degrees*, to which they annex no correct idea; and expreſſed a hope that, at no very diſtant period, this improvement might be expected in ſcience.

In venturing to call in queſtion the truth of the received doctrines, it was not my intention to depreciate the diſcoveries of a Black, a Crauford, a Lavoiſier, or a Cavendiſh; men whoſe memories will be cheriſhed, while the world endures, by every lover of ſcience. Their genius, their perſevering induſtry, their penetrating judgment, firſt brought to view thoſe luminous facts which muſt ſerve as the baſis of all true theory reſpecting the ſubjects of which they treated; and thoſe facts will remain, whatever may be the fate of theories already eſtabliſhed, or of others that may ſuperſede them.

But as truths, once eſtabliſhed, become a common property in ſcience, thoſe whoſe genius would never have diſcovered are not debarred the uſe of them. It may alſo be obſerved, that the original diſcoverers of important facts have often, in drawing their inferences and making their deductions, given an undue weight to conſiderations that were no other way connected with the ſubject than by being unfortunately *ſtumbled over* in ſome part of the journey, in which they chanced to be out of the right road; for who, that firſt explores an unknown region, can be expected to get on without interruption or impediment? Such accidents, however, have an unavoidable influence on the mind; and to exempt any man from their conſequences, when they occur, would be to deny that he is human.

Thoſe who are not aware of the difficulties of this kind with which genius has to encounter, can never rightly appreciate the merits of thoſe who, in ſpite of their influence, give an unbiassed account of the facts they discover. It is one of the greatest efforts of human probity to give them undisguised, unwarped by theory. This praise is due to the men to whom I have alluded: their labours, therefore, are invaluable, even if it should be proved that, in some few instances, they have been mistaken in their inferences.

It was my intention, in addition to the facts generally mentioned in my former essay, to have brought forward, on the present occasion, a number of further evidences of the substantiality of heat; but my state of health, since our last session, has been such that I have not been able to go into a wide field. I shall, however, bring to the recollection of the Society a few well-known facts, which, according to my view of them, serve to prove that heat is a substance *sui generis*.

Volume, as I frequently had occasion to notice in my former essay, is a characteristic of matter; but liquids, on being mixed, are reduced in volume, without parting with any thing except heat—therefore heat is matter.

The same effects take place when gases are presented to any substances to which they can unite. Thus, muriatic acid gas easily combines with ice cold water; but in doing so it parts with its heat, which forms the greatest part of its volume. The gas is in fact decomposed: one of its principles, the muriatic acid, joins the water, and its other, the heat, being thus separated from its former associate, then, according to the general law, first heats the substances nearest to it, the acidulated water and the containing vessel, and afterwards passes off to surrounding objects till equilibrium is restored. If ice, instead of water, be presented to this gas, it will be melted by it as speedily as if thrown into the fire.

If certain gases be united, this diminution of volume, this passing off of matter, (which, though in union in the ingredients, finds the capacity of the new compound for it so different that it must diffuse itself,) is, if possible, still more striking. When, for example, oxygen gas and nitrous gas, in the proportions necessary to form nitrous acid, are presented to each other, in a bell-glass, over water, what an

abridgement

abridgment of volume takes place! It cannot be otherwise, the capacity of the new compound for heat being so much less than the sum of that of the ingredients; for the moleculæ now respectively arrange themselves with each other in such a manner, that they can afford but a small quantity of lodging-room for the heat, compared with what it occupied in the gases; and it is therefore forced, by the general law, to diffuse itself among and through the contiguous bodies till each is with each in equilibrium. But each thereby receives an increase of volume, that is, an increase of matter; and it is extremely probable that, if we could get at the sum of their increase, it would be found exactly equal to the difference between the volume of the gases before mixture and that of the acid produced.

If any quantity of nitrous gas be joined to twice its bulk of atmospheric air, we all know that the same effects take place as in the case just mentioned; that is, the substance *heat* changes its associates.

We may observe here that, as heat passes freely through all bodies, and tends to an equilibrium; and as this equilibrium, when established in any system of bodies, is sometimes higher than at others, it seems far from being correct to talk of heat being then *in a state of confinement.* If a colder body be made one of this system it will soon be seen that the heat, instead of being latent in the other bodies, finds itself *free* to pass from them into the colder body till it has received the portion suited to its capacity compared with that of the others.

If there be any state in which heat is less in a state of confinement than another, it is when in equilibrium; and it is only when it has, by any means, been accumulated in individual bodies, in greater proportion than, by their capacity, compared with that of the surrounding bodies, they ought to be supplied with, that any thing like restraint can be considered as imposed upon it. The impediments that retard its equal diffusion, are, in fact, the only restraints it experiences; and to me this appears so obvious, that I cannot help wondering how men of science should ever have thought of calling it *free* in such circumstances. It is free, to be sure, but not in their sense of the word; for it has restraints to overcome; but

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when in equilibrium it suffers no restraint whatever, for then every individual substance has its own proper quantity of the common stock.

I shall now examine for a little several facts which appear to prove, if duly weighed and applied, that heat possesses another characteristic of matter, I mean GRAVITY. If this fact can be established, we shall have another strong proof of the substantiality of heat; and the facts I mean to bring to your recollection are, I think, sufficient to establish it as a truth—a truth which has been forcing itself on the notice of men, for many centuries, with much stronger evidence than many others which have received general admission, though it has not only been overlooked, but many experiments have been brought forward to establish the opposite.

Heat poured into bodies lessens their specific gravity; and yet heat may not be weighed, even comparatively!! There appears to me to be something so extremely repugnant to reason in this assertion, that ever since I have dared to reason for myself I have found myself forced to refuse my assent to it. If heat lessens the specific gravity of bodies, (and we can even determine, in many cases, the ratio in which this takes place,) I think we are then weighing the heat itself, or, rather, the difference of the quantity in a body at one temperature and at another.

In the various direct attempts that have been made to weigh heat, I fear philosophers have been following a plan just about as rational as it would be in the inhabitants of the ocean to attempt to weigh water by employing a balance suspended in the medium that surrounds them, and putting into one shell a substance that to them should seem wet, and into the other a substance which they might call dry!

If we could abstract heat entirely from a body, as we can air from a glass balloon, we should be at no loss in weighing it: but is there no other way of weighing air but that one? If I take a bladder containing an unknown quantity of air, I easily find out how much weight is required to sink it in water: if I afterwards pour into the bladder a known bulk of air, I can come at a knowledge of the weight of the air so added by attending to the quantity of weight now necessary to ſink the bladder in the water, the ſpecific gravity of the water being known. But if I weigh, in water, any ſubſtance containing an unknown quantity of heat, and find that, upon adding a known bulk of heat to the body, it will then require a leſs weight to make it ſink, I am to draw no inference reſpecting the weight of the caloric that has been added!! Is this reaſonable? Should philoſophers ſtop ſhort in this manner, and not ſeize upon the truth which ſuch effects exhibit to them? Is it not obvious, in all experiments which have for their object the determining the ſpecific gravity of any body in different temperatures, that they are doing nothing but weighing comparative quantities of heat, by obſerving how much water is diſplaced by thoſe quantities?

Though I think the truth I have juſt ſtated is ſelf-evident, I hope I ſhall not be thought tireſome if I endeavour to ſet it in a clear point of view by an illuſtration.

If I ſuſpend a piece of metal in water at one end of a balance, and if to this metal I join a ſmall bit of any ſubſtance lighter than water, ſay a bit of cork, will not the maſs, by having its abſolute gravity increaſed, have become ſpecifically lighter? I am now conſidering the metal and cork as one compound body. In this caſe no one heſitates in admitting that the addition of the cork, though poſſeſſing abſolute gravity, is the cauſe of the compound body appearing lighter when weighed in water; a medium more rare than one of the ingredients, but denſer than the other: but *if heat inſtead of cork had been added to the metal, would not the effect have been the ſame*, an increaſe of volume and a diminution of ſpecific gravity? And for the ſame reaſon too, the metal being heavier but the heat lighter than water.

Let us reverſe the caſe.—A compound body, iron and cork, poſſeſſes a certain ſpecific gravity. Remove the cork, that is, take away from the maſs a portion of its abſolute bulk and weight, and on weighing what remains it is found to be increaſed in weight—in water.

Yet, if I detach from a piece of gold, ſilver, platina, copper, a certain quantity of heat, by mechanical means, and thereby reduce its volume, I am not to conclude, though I find its ſpecific gravity increaſed, that the matter expreſſed poſſeſſed abfolute gravity, though lefs fpecifically than that of water? Is this confiftent with found phyfical principles? I think not: for the fame effects fhould always be afcribed to one caufe.

It is admitted on all hands that caft metals, that is, metals in their largeft natural volume, are fpecifically lighter than when drawn into wire or rolled into plates, that is, when reduced in fize, by having fomething feparated from them, namely, heat.

If a piece of denfe wood, that has been foaked in oil or alcohol, be weighed in water; and if a portion of the imbibed liquid be expreffed, and the wood be again weighed, its fpecific gravity will be found to have increafed; becaufe the fluid expelled from it was lighter than water. Every one can *fee* and *feel* the oil or alcohol driven out of union with the wood; and every one may feel the heat driven out of metals by paffing them through rollers. Is it becaufe heat is only cognifable, in the firft inftance, by one grofs fenfe that its exiftence as matter is denied? It may be feen as well as felt, as I have before had occafion to remark; for when driven from one body, the volume of which is in confequence diminifhed, it enters into others, and theirs become *vifibly* enlarged. If it were not fo, even the common thermometer could have no exiftence.

I fhall here mention the different fpecific gravities of a few metals in their caft ftate, and when a portion of heat has been feparated from them, by their moleculæ being brought fo much clofer together, by mechanical means, as to increafe the power of aggregation, or, in other words, to diminifh their capacity for heat.

| | Caft. | Hammered. | Rolled. | Drawn into wire. |
|---|---|---|---|---|
| Pure gold | 19258 | 19362 | | |
| Standard gold | 17486 | 17589 | | |
| Pure filver | 10474 | 10511 | | |
| Pure platina | 19500 | 20377 | 22069 | 21042 |
| Copper - | 7788 | | | 8878 |
| Brafs - | 8396 | | | 8544 |

The fact is, I fufpect, univerfally true, that where the fpecific gravity of a body is diminifhed, its abfolute gravity is and muft be increafed; and thefe terms ought always to be confidered

confidered as convertible. When a diminution of the fpecific gravity is declared, an increafe of the abfolute gravity is by the fame enunciation afferted, whether the fpeaker means to do fo or not. Now, in the cafe before ftated, the diminution of the fpecific gravity is admitted; and therefore a queftion naturally prefents itfelf—Why has the increafe of abfolute weight not been hitherto obferved? I take the reafon to be this: they attempted to determine it *in the air*; overlooking this plain fact, namely, that air may be confidered as bearing the fame relation to heat that water does to gold, or rather, to a fubftance many times heavier, if fuch could be found; that is, the air, though a rarer fubftance than the folid bodies weighed in it, is a denfer one than heat; and they have been demanding, that a fubftance fpecifically lighter than air fhould defcend in it. In other words: that the laws of nature fhould be inverted, and that the heavier fluid, air, fhould afcend to make room for a lighter one, heat, to defcend.

But Nature will not bend to our whims and fancies. We muft court her, and take her as fhe is, or remain in error. The heated body, though increafed in fize, remains in equilibrium in the balance; and it ought to do fo (if not to afcend), being buoyed up by a greater quantity of air than before it was heated. But is this the only cafe in which that effect takes place, and where we know at the fame time that not only volume but real fubftance is added to one end of the beam? No: a bladder capable of eafily containing a gallon of air will always weigh the fame (in air) whether you put into it a pint, a quart, or a gallon.

Aye, fays a caviller, but you have not put into the bladder any thing heavier than the furrounding medium, though you have put in a real gravitating fubftance; therefore the bladder cannot weigh heavier. Inftead of anfwering him, I fhall leave him to his own meditations.

Are philofophers always to continue in the belief that bodies can be made fpecifically lighter and heavier at pleafure, without any thing being either abftracted or added? Can a nonentity produce the effects of which we have been fpeaking? or, is gravity itfelf a nonentity? It either is, or heat is material. But, when I consider the rapid advances that have been made in various branches of science within these few years past, I cannot allow myself to believe that its votaries will much longer doubt of the existence of the most powerful and most generally diffused substance in nature, or long remain of the opinion, "*that all attempts to discover any effect of heat upon the apparent weight of bodies will be fruitless.*"

The ingenious philosopher (Count Rumford) whose words I have just quoted, and to whom every inquirer into Nature must feel himself highly indebted for the unwearied patience with which he has watched and traced her steps in many of her most intricate operations, and for the zeal which he has manifested in applying scientific truths to the common purposes of life, will be among the first to abandon the opinion; for, when he shall have better considered the subject, he will find the evidence lies wholly on the other side. If the opinions I have controverted were held only by men, like him, enlightened and candid, I should be sanguine enough to believe that what I have advanced would suffice to convince all of their absurdity without the necessity of saying a word more on the subject: but we know well how difficult it is for the human mind to shake off imbibed prejudices, especially when they have been theorised, and applied, like the salt, sulphur, and mercury, of the alchemists, and the phlogiston of the Stahlians, to explain all the phænomena of nature; and therefore I cannot promise myself, that the mere treaders in trammels and day-labourers in science will adopt my ideas without something more level to their capacity being first offered in addition to the evidence already produced. Indeed it would be unreasonable to expect that men of the cast to which I now allude should at one glance perceive the force of truth when presented to their view. If they ever apprehend truth, it is when it chances to be a part of the system they have been taught; and that system, however false, they always adhere to, till every person of superior intellect has abandoned it.

With a Society, however, instituted for purposes like ours, truth will meet with a proper reception. Those who are associated

associated for the express purpose of exploring philosophical facts, will ever lend a ready hand to separate the fine from the dross; and, I doubt not, will by their labours give form and solidity to the structure for which I have humbly endeavoured to collect a few materials.

I intended, before concluding these remarks, to offer a few experiments for the consideration of the Society, which, if properly conducted, would, I persuade myself, furnish direct evidence of the gravitating power or property belonging to heat in common with other kinds of matter: I consider the point as established by the arguments already advanced, but I mean to say, that, by certain experiments, (if I have been under no mistake in the reasoning that led me to frame them) its absolute weight, in certain specific cases, may, I think, be ascertained; but having run the present essay to a greater length, and encroached further upon the time of the Society than was perhaps proper, I shall reserve them for a supplement, which I may offer hereafter, or perhaps make them the subject of a future essay.

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## XXI. *Account of the Manner in which the Tartars and Kalmuks make their Kumis, or fermented Mare's Milk* *.

TAKE of mare's milk of one day any quantity; add to it a sixth part of water, an eighth part of the sourest cow's milk that can be got, but at a future period a smaller portion of kumis will better answer the purpose of souring; cover the vessel with a thick cloth, and set it in a place of moderate warmth, leaving it to rest for twenty-four hours; at the end of which the milk will have become sour, and a thick substance gathered at top: then with a stick, made at the lower end in the manner of a churn staff, beat it till the thick substance above mentioned be blended intimately with the subjacent fluid: let it rest twenty-four hours in a high narrow vessel like a churn. The agitation must be repeated as before, till the liquor appears to be perfectly homogeneous; and in this state it is called *kumis* (or *koumis*), of which the taste

* From *Eton's Survey of the Turkish Empire.*

ought

ought to be a pleaſant mixture of ſweet and ſour. Agitation muſt be employed every time before it is uſed. When well prepared in cloſe veſſels, and kept in a cold place, it will keep three months, or more, without any injury to its quality.

It ſerves both as drink and food, and is a reſtorative to the ſtomach, and a cure for nervous diſorders, phthiſis, &c.

The Tartars diſtil this fermented milk, and obtain from it a ſpirituous liquor, which they drink inſtead of brandy.

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XXII. *Singular Caſe of Dropſy: communicated in a Letter from Dr.* CHARLES SMITH, *of New-Brunſwick, New-Jerſey, to Dr.* J. R. B. RODGERS, *Profeſſor of Midwifery and of Clinical Medicine in Columbia College*.*

A CASE of chylous dropſy (if I may uſe the expreſſion) lately occurred in my practice, which I judge to be rather an uncommon one; at leaſt it is new to me, and my memory does not ſerve me with a ſimilar inſtance on record brought to a favourable termination.

In December 1799, T. L. of South-River, applied to me for worm medicines for a boy twelve years old, deſcribed to have an enlarged abdomen, and very inſatiable appetite. Calomel, pink-root, &c. were adminiſtered and repeated without any beneficial effect. On viſiting the lad afterwards, it appeared evident that his abdomen contained a large quantity of ſome fluid, ſo much as to prevent a recumbent poſture altogether. He laboured under none of the other ſymptoms of dropſy, ſuch as œdematous ſwellings, or much relaxation of the ſolids: he only appeared ſomewhat leaner than uſual.

The patient was brought to town, a few days after, and tapped. On withdrawing the ſtilette, you may judge our ſurpriſe to find a moſt pure, white, and fragrant chyle, or milk, to follow, which continued to flow until we obtained between ſeven and eight quarts. This chyle had rather more of a chalky-white colour than cow's milk. It was perfectly ſweet and pleaſant both to the ſmell and taſte; and, after ſtanding through the night, afforded a good cream, though

* *American Medical Repoſitory*, Vol. III.

not

not quite so much as is usually obtained from the same quantity of cow's milk.

After the operation, the boy was restored to his usual feelings, and, in fact, seemed to have no complaint, save a constant craving for food. He was taken home three days after, and I heard no more of him for fourteen days, when I was requested to visit him in the country. I found him, in all respects, as before, save a greater degree of emaciation; and, by repeating the operation, I obtained a fluid of the same kind, and nearly the same quantity, as before. From this time until the 20th of March I heard nothing of my patient: as his friends had determined to yield him to his fate, provided the last attempt should prove unsuccessful, I had, in my imagination, numbered him with the dead. Having occasion to visit the neighbourhood at this time, I was agreeably disappointed in finding him in perfect health, without any intumescence of the abdomen, and with an appetite reduced to due moderation.

It is evident, from the circumstances of the above complaint, that some of the larger chyliferous vessels were either eroded or ruptured; and the emaciation which was taking place, and the short space of time which had elapsed between the operations, induced me to conclude the cure beyond the bounds of our art. I therefore contented myself with ordering a few doses of calomel and laudanum, with a view to excite absorption; but more with a view to satisfy the minds of those concerned, than from a prospect of any permanent utility. I advised an adherence to solid rather than fluid food; and, being requested, permitted a moderate use of Geneva.

On inquiry, I learned that no medicine of any kind had been given after the day of the second operation; and, by the positive order of the mistress of the family, the patient was entirely restrained from the use of every fluid, except gin, and confined to bread toasted brown, and fresh meats, boiled or roasted, without pepper or salt. This regimen was enforced, without the least relaxation, for the first ten days. For the two succeeding weeks, a small portion of water was sometimes added to the gin, but never to exceed it in quantity. After which period, perceiving no tendency to the former complaint, the boy was permitted to return gradually to his ufual mode of living, and has fince continued in good health. During the time of the above regimen, he was two or three times fairly intoxicated, and that too by defign.

You will, doubtlefs, efteem the above mode of treatment fuch as would hardly have been ventured on by a judicious practitioner; and yet to it, I am inclined to think, the boy owes his life.

From the nature of the food and drink, the quantity of chyle generated muft have been much lefs than ufual. And, admitting that a proportion of it was difcharged into the cavity of the abdomen, we may fuppofe this to have been taken up by the increafed action of the abforbent veffels of that cavity, excited into more than ordinary energy by the ftimulus of the gin. The difeafed veffel or veffels being lefs diftended than heretofore, would, of courfe, be more difpofed to heal.

If you, Sir, who are fo competent a judge in matters of this kind, conceive the above cafe can be of any fervice to the public, you have my permiffion to difpofe of it in fuch a way as may appear to you moft likely to promote that end.

*Quære.* How far would the above regimen fucceed in afcites, after the operation?

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## XXIII. *Proceedings of Learned Societies, Mifcellaneous Articles, and new Publications. March* 1801.

### ROYAL SOCIETY OF LONDON.

On February 26, the reading of Count de Bournon's paper on the cryftals of arfeniat of copper and iron, found in Gorland mine, in the county of Cornwall, was concluded.

March 5th, 12th, and 18th, were entirely taken up in reading the chemical analyfis of the arfeniats of copper found in Gorland mine. This paper was of a nature which prevents its being detailed. The experiments were made and defcribed in a moft accurate, mafterly, and elegant manner, by Richard Chenevix, Efq. F.R.S., and will be of the higheft importance to thofe concerned in copper works, as well as to the fcientific world in general.

FRENCH

## FRENCH NATIONAL INSTITUTE.

The following account of the labours of the Mathematical and Phyſical Claſs of the Sciences during the laſt three months has been read.

*Chemiſtry.*—C. Berthollet has proved that the propagation of the chemical action is leſſened, 1ſt, by the weakneſs of that action: 2dly, by conſtitutional changes to which the ſubſtances that exerciſe it are ſubject. He has eſtabliſhed the limits of the chemical knowledge hitherto acquired in regard to vegetable phyſiology. He has ſhown alſo that motion accelerates the communication of heat, by bringing nearer thoſe parts which are at a diſtant temperature; ſo that their reciprocal action becomes thereby more lively and inſtantaneous; but that it ought not thence to be concluded that liquids and elaſtic fluids are incapable of tranſmitting heat.

Guyton is employed on the means of purifying the air and checking the progreſs of contagion. He has carefully examined all the methods hitherto followed for this purpoſe, and even his own, and determined thoſe which ought to inſpire the greateſt confidence. He has read alſo a memoir on the preparation of mortar, lime, and different kinds of pozzolano, in which he compares the nature of theſe ſubſtances, and gives the reſult of experiments, made on a large ſcale, even under the water of the ſea, with ſome matters which he propoſes to ſubſtitute in the room of the pozzolano of Italy.

*Experimental Philoſophy.*—Hallé has given an account of experiments reſpecting galvaniſm, either repeated or made for the firſt time at the School of Medicine by means of Volta's apparatus. The general reſult of them is a proof of the identity of the galvanic principle and electricity.

*Meteorology.*—Teſſier has preſented a ſeries of queſtions to be propoſed to the conſtituted authorities and the correſpondents of the Inſtitute in the departments, in order to obtain from them every information neceſſary to make known the extent of the effects of the ſtorm which took place in the month of November.

Lamarck has endeavoured to fix the nomenclature of certain meteors. According to his opinion, hurricanes and ſqualls take place only under certain clouds, which conceal the cauſe of them: they traverſe a band of the atmoſphere in a ſtraight line, and in the direction of the wind by which they are impelled; produce only tranſient effects, and either do not make the barometer fall, or make it fall very little. Storms, on the other hand, extend their effects to a diſtance; continue at leaſt ten or twelve hours, and may even prolong their duration to thirty-ſix; they do not come on of a ſudden, and make the barometer fall. According to theſe obſervations, the violent winds in November laſt were the reſult of a real ſtorm, and not of a hurricane.

*Botany.*—Ventenat, in a memoir on the plants called *arum*, has ſhown, that ſeveral of thoſe which the botaniſts have hitherto referred to that claſs are ſo different as to authoriſe their being formed into a particular genus, the characters of which Ventenat determines, and which he calls *caladium*.

Beauvois has preſented ſeveral drawings of plants growing in the country of Oware and Benin, a Flora of which he intends ſoon to publiſh. He has given a particular deſcription of a new genus of the family of the *cucurbitæ*, which he calls *myrianthus*; the only one of that family which is a tree properly ſo called. It might be diſtinguiſhed by the name of the *melon-tree*.

Ramond has diſcovered in the Pyrennees a new genus of plants which approaches near to the *colchica, bulbocoda,* and ſaffron: he has called it *minderera* with the Spaniards, and has ſent a figure and deſcription of it. He has alſo made a curious obſervation, hitherto unique of its kind: he has found the aquatic ranunculus flouriſhing, not as uſual at the ſurface of the water, but at a certain depth under it.

Picat-Lapeyrouſe has announced that he propoſes to publiſh a particular deſcription of the plants named *ſaxifragi*; and he has communicated the motives which induce him to do ſo, and the baſes on which he propoſes to eſtabliſh it. The leaves, according to which he has hitherto diſtinguiſhed theſe plants, do not afford conſtant characters: beſides, in this genus there are more hybridæ ſpecies; that is to ſay, ſpecies ariſing from a mixture of two, than has been hitherto believed.

believed. Lapeyroufe has fought for their diftinguifhing marks in the figure, the proportion, and the relation of the parts of fructification: he has divided the whole genus into feveral natural groupes, and collected from the works of the old botanifts, and in their herbals, a more correct fynonymy than any hitherto obtained.

*Zoology.*—Lacepede has defcribed a ferpent hitherto unknown to naturalifts; he has formed of it a genus to which he gives the name of *erpeton tentaculatum.* Its characters are, that it has a row of large fcales below the body, and the lower part of the tail covered with fmall fcales like thofe of the back.

Cuvier has made us acquainted with the prefent ftate of his refearches in regard to quadrupeds; he has now found twenty-three kinds of thefe animals, none of which has ever been feen alive on the earth.

*Medicine.*—Hallé has given an account of the fymptoms of that contagious malady which lately occafioned fo much devaftation in Spain. He has proved that it was not the plague common in the Levant, but that malady known in America under the name of the *yellow fever.*

Lafoffe has read obfervations on different ligaments in man and animals; and by reafoning and practical examples has fhown that there are cafes in which the cutting of thefe ligaments may be highly advantageous.

## PHILOMATIC SOCIETY.

Labillardiere read a memoir on two fpecies of the litchi of the Moluccas. The two fpecies here defcribed are originally from China, and were introduced into the Moluccas by the Chinefe, who inhabit thefe iflands. One of them, called *ramboutan* by the Malays, is the *nephelium lappaceum* Linn.; the other, which they call *ramboutan-aké,* is unknown to botanifts.

The *nephelium* was fo little known that it has been fucceffively claffed among the *compofitæ,* the *amentaceæ,* and the *euphorbia.* Labillardiere proves that it belongs to the family of the *faponariæ*; and he even unites it to the genus of the litchi. Its calyx has four or five divifions covered with

hair,

hair, and no corolla. It has from four to six stamina inserted in the pistil, and of very short duration, which made it be considered as a *monoecia*. Its ovarium has two rounded lobes, and its style divides itself into two hollow stigmata. One of the lobes of the ovarium generally miscarries, and the other forms a red oval berry full of sharp points, terminating in hooks and covered with a coriaceous and tuberous rind. The kernel is oval, a little flatted, and lodged in a pulpy substance, to which it adheres by the base. It is here seen that this tree differs from the litchi only by the absence of the corolla, and because it has only from four to six stamina instead of six or eight. The points of its fruit, though long, are not sufficient to make it be considered as a distinct genus; since the fruit of the common *litchi* is also interspersed with small points, which arise, in the like manner, from tubercles circumscribed by irregular polygons. The pulp of this fruit is somewhat acid: it is used in the Moluccas for allaying the thirst of those attacked with malignant fevers. The surgeon to the expedition sent in quest of La Peyrouse used this juice with success for the dysentery. The second covering of the fruit does not appear to Labillardiere a character sufficient for retaining the genus *nephelium*; he founds his opinion on the example of the *magnifera indica*, the fruit of which have sometimes a second covering almost ligneous, which is wanting in the other varieties.

The *litsea ramboutan-aké* differs from the preceding by the divisions of the calyx being more obtuse; the stigmata pointed; the being interspersed with tubercles truncated at the summit, and the external covering thicker; by its rising only to the height of fifteen or sixteen feet; and by its branches being horizontal, and its leaves having from six to eight folioles. Its pulp is as agreeable to the taste as that of the *litsea chinensis*. The taste of its kernel resembles that of a nut. An oil similar to olive oil, and superior to that of the coco nut, is extracted from it.

The same author read another memoir on a new genus of palm called *arenga*. It is the *palma indica vinaria secunda, Saguerus seu Gomutus*. (Rumph. Herb. Amb. Vol. I. p. 57.) It constitutes a new genus, which Labillardiere calls *arenga*, from

from *areng*, the name given to it in the Moluccas. Its natural characters are as follow:

*Male flowers.*—The ſheath of one piece; the ſpadix much ramified; calyx divided into ſix folioles; the three exterior ſhort, in the form of a heart, and having a protuberance at their baſe; the three interior oval, and in alternate order with the former. Stamina fifty or ſixty filaments, almoſt as long as the interior folioles, and the reſt almoſt united or adherent to a ſhort receptacle which riſes from the centre of the flower. The antheræ linear, indented like a heart at the baſe, and adhering to filaments the ſummits of which project over them.

*Female flowers* on the ſame ſtalk. The ſheath and ſpadix as in the males. The calyx divided into ſix folioles; the three exterior ſemicircular, the three interior much larger, and having the form of an iſoſceles triangle. Piſtil: a ſimple oval ovarium, terminated by three pointed and ſeſſile ſtigmata. Fruit: almoſt ſpheric, bacciform, with three cells containing each three ſeeds bearing three protuberances oppoſite to the ſtigmata; ſeeds oval, convex on the exterior and depreſſed on the interior ſide, where they have two facets ſeparated by an angle. The external ſkin of each ſeed thin, friable, and covered on the outſide with aſperities. The embryo lateral, and ſituated in a peculiar cavity.

The *arenga* differs from the *boraſſus* by its lateral embryo, its ſheath of one piece, and, in particular, by its fifty or ſixty ſtamina: a remarkable conformation in a family, all the genera of which have ſix ſtamina, except the *caryota* Linn. and the *manicaria* Gærtn. which have from twenty to twenty-five.

The only kind of *arenga* known is the *arenga ſaccharifera*, which riſes to the height of fifty or ſixty feet; its pinnated leaves are about fifteen or ſixteen feet in length; the folioles are dentated at the extremity, and have one or two appendages at their baſe: the petioles are broad towards their baſe, and furniſhed with long black filaments, of which the Malays make very durable ropes and cables. The petioles are employed in the conſtruction of their houſes, and the folioles for covering them.

A very ſaccharine liquor is obtained from this palm by making inciſions in it: if properly managed, the liquor may be be obtained from it for more than half the year. By simple evaporation this liquor produces a kind of sugar, which has the colour and consistence of chocolate newly made; but which, in all probability, might be susceptible of purification. Excellent preserves are made of the kernels and young fruit of the *areng*, and very good sago is extracted from the trunk.

Decandolle read a memoir on the vegetation of the misseltoe, which, as is well known, is a parasitic plant, that grows on several trees and in all directions. Duhamel has given a very accurate and interesting account of it. Respecting this singular vegetable, Decandolle made the following experiments:

1st. To prove that the misseltoe derives its nourishment from the tree on which it exists, he immersed in water, coloured red with cochineal, a branch of an apple-tree on which a misseltoe was growing. The coloured water penetrated the bark and wood of the apple-tree and passed into the misseltoe, where its colour was even more intense than in the tree itself. It does not, however, appear that there is a real anastomosis between the fibres of the misseltoe and that of the apple-tree; but the base of the misseltoe is surrounded with a kind of cellulosity where the fibres of the apple-tree seem to deposit the sap, and where those of the misseltoe seem to imbibe it. The pith of the misseltoe is green in the young stems; and, by inspecting a transversal section of the vegetable, the opinion of Desfontaines, that the cellular tissue is an external pith, rendered green by the light, seems to be fully confirmed.

2d. Decandolle took a branch of an apple-tree bearing a misseltoe, and immersed the latter in coloured water. Its leaves dropped, and the cicatrices became red. The liquor followed the ligneous fibres of the misseltoe, descended into its roots, passed into the wood of the apple-tree, and descended towards its roots.

3d. Having taken two branches of an apple-tree bearing two misseltoes of equal size, and having stripped of their leaves both the branches and one of the misseltoes, he introduced the ends of these branches into tubes hermetically sealed, and filled with water; he then inverted these tubes in a vessel containing mercury, and observed that the misseltoe

 which

which had leaves raiſed the mercury 4·64 inches in nine hours, while the miſſeltoe deprived of its leaves raiſed it only 1·5: the leaves of the miſſeltoe, therefore, act the ſame part in regard to the apple-tree as the real leaves of that tree.

4th. Having taken two miſſeltoes with leaves, one of which was implanted on a part of the root of the apple-tree, and the other immerſed immediately in water; and having diſpoſed them as in the preceding experiment, the firſt miſſeltoe raiſed the mercury about 4·48 inches; the other once raiſed it ·42, and another time did not raiſe it at all. This ſingular experiment ſhows, that the miſſeltoe, by itſelf, is almoſt entirely deſtitute of the faculty of raiſing the ſap.

Decandolle on this occaſion obſerves, that the faculty of raiſing the ſap by a root is intimately connected with a perpendicular direction. In regard to their nutrition, he divides vegetables into two claſſes. The firſt receive their nouriſhment through their whole ſurface; do not live but in one ſurrounding medium, of air, as the lichens; of water, as the fuci; or of earth, as muſhrooms. Vegetables of the firſt claſs have no tendency to a perpendicular direction. Thoſe of the ſecond receive their nouriſhment through a determinate place called their root: they always live in two or three ſurrounding mediums; in the earth and water, like the *potamogetons*; in water and air, as the *ſtratiotes*; in the earth and air, as the oak; in the earth, water, and air, as the nymphæa. The plants of the ſecond claſs all tend to the zenith with more or leſs energy.

Decandolle has alſo read a memoir on the pores and the bark of leaves. The word *gland* in the anatomy of animals ſignifies a ſecretory organ; but in the anatomy of plants this name has been given to ſeveral organs which are not, or at leaſt have never yet been known to be, ſecretory organs, and which differ conſiderably from each other. The miliary glands of Guettard have particularly fixed the attention of Decandolle; they are thoſe which De Sauſſure has deſcribed under the name of *cortical glands*, and which by Hedwig are called *vaſa lymphatica cuticulæ*. Decandolle gives them the name of *cortical pores*; an appellation that relates only to their form and their poſition, which are certain things, and

 not

not to their use, which is uncertain. He first examines their essential nature, and then follows their variations in the different parts and different classes of vegetables, and under various circumstances. From these facts he endeavours to determine their use.

The cortical pores form part of the cortical tissue of the leaves. It may be seen by the microscope that they are oval, and surrounded by an oval border, which connects them, by two or three fibres, to the rest of the tissue. The meshes of the tissue are more lengthened, and always without pores on the fibres; the bristles, on the other hand, are always placed on the fibres or ramifications. Decandolle is of opinion that these cortical pores are placed at the extremity of the fibres which compose the leaf. This idea was suggested to him by the conformation of the *crassula, lactea, cotyledons,* &c. A bundle of fibres traverses the parenchyma of their leaves, and ends at the bark; the place where it ends is an assemblage of pores, whereas scarcely any are found on the rest of the surface. This idea is confirmed by the pores being very numerous on coriaceous leaves, and very little so on those that are pulpy, which have more juice and fewer fibres.

The cortical pores are found in particular on the leaves. The leaves of herbs, in general, have some of them on both faces, and those of trees on the lower surface only; which coincides with the experiments of Bonnet on suction. The stems have no pores, except those of plants which are very herbaceous; such as the *cucurbitæ*, grasses, and those which are destitute of leaves, as the *cactus, ephedra,* &c. The roots never have pores. Some are found on the stipulæ, and the foliaceous and durable bracteæ. The calices in general are furnished with them; but, on the other hand, the corollæ have none: this rule, however, is liable to some exceptions, which Decandolle proposes to explain in a particular memoir. The pulpy pericarpia are unprovided with pores, but those which are coriaceous have them. The skins of seeds have none, but they are found on the seminal leaves. None of them, however, are found on the cotyledons which remain on the ground, nor on those of French beans.

If the bark of various families be examined, it will be

 found,

found, that in plants really destitute of cotyledons, such as mushrooms, the *byssi*, *fuci*, lichens, and hepatica, no pores are found, nor even real bark, nor perhaps epidermis. This absence of the epidermis explains why mushrooms are so putrescible; why the fuci, &c. imbibe water so easily; why coloured water penetrates into the leaves of lichens, which does not take place with other plants. Plants which have cotyledons have bark: mosses have no cortical pores; ferns have them, but only below. The monocotyledons with longitudinal fibres have pores between the fibres; and hence the distinguishing characters of the different families may be deduced. The cortical pores are found only on plants or parts of plants exposed to the air, and never on those which are under water: immersed plants, therefore, are destitute of them, and floating leaves have them only on their upper surface. Decandolle has seen an aquatic ranunculus, which usually has no pores, acquire a great number when it grew in the open air. He also made an inverse experiment, and found that mint, made to grow under water, sent forth leaves without pores.

Light also is necessary for the development of pores. Blanched plants have none; cresses which grew exposed to the light of six lamps had only half the number they usually have when in the open air. The coats of bulbous roots have none in the parts below ground; but those parts exposed to the light and the air have pores.

The cortical pores do not serve for the production of the blue pollen, for plums have no pores; oily plants, which have few pores, have blue pollen in abundance; and from twelve to fifteen thousand plants have pores without producing blue pollen.

They serve only for sensible transpiration, for the diversity of the matters exhaled seems to indicate a diversity in the organs: besides, they are found in all vegetables, and that function takes place only in some.

They do not serve for the escape of oxygen gas, though the want of them in blanched plants and the corollæ gives reason to think that they are destined for that purpose; but they are found in leaves coloured red which emit no air: they are

 wanting

wanting in aquatic plants, moſſes, green lichens, green fruits, and the upper ſurface of ſeveral plants which give oxygen gas.

Decandolle is of opinion that the cortical pores ſerve, 1ſt, For inſenſible tranſpiration; and indeed this function is exerciſed in all terreſtrial vegetables; it is unknown and improbable in aquatic plants; oily plants, which have few pores, tranſpire little, but herbaceous plants tranſpire a great deal; the corollæ and blanched plants tranſpire very little: in a word, it may be eaſily conceived that the lymph, after having traverſed the fibres throughout their whole extent, and having depoſited in its courſe the alimentary moleculæ, is exhaled at their extremity. 2d, The author thinks that, in certain caſes, theſe pores may ſerve for the abſorption of vapours; and he thereby explains the agreement of his obſervations with thoſe of Bonnet on ſuction, the effect of watering on withered plants, and the increaſe of oily plants when hung up in the open air. He proves by an experiment that oily plants, when cut and expoſed to the air in a dry place, gradually loſe their weight; but that it is reſtored to them by immerſion in water. It may eaſily be comprehended, if Sennebier's theory of the aſcent of the ſap be admitted, that when the extremity of the fibre is more humid than the air, it gives up to it its moiſture; and that, if it is drier, it attracts that of the air.

### BUTTER.

"The butter, which is moſtly uſed in Conſtantinople, comes from the Crimea and Kuban. They do not ſalt it, but melt it in large copper pans over a very ſlow fire, and ſcum off what riſes; it will then preſerve ſweet a long time if the butter was freſh when it was melted. We preſerve butter moſtly by ſalting. I have had butter, which when freſh was melted and ſcummed in the Tartar manner, and then ſalted in our manner, which kept two years good and fine taſted. Waſhing does not ſo effectually free butter from the curd and butter-milk, which it is neceſſary to do, in order to preſerve it, as boiling or melting; when then ſalt is added, we certainly have the beſt proceſs for preſerving butter. The melting or boiling, if done with care, does not diſcolour or injure the taſte."—*Eton's Survey of the Turkiſh Empire.*

CHEMICAL

## CHEMICAL NOTICES.

The following is an extract of a letter from U. P. Salmon, Physician to the French Army in Italy, to Professor Mascagni, of Sienna:

"Brugnatelli is much employed at present in repeating the experiments of Volta on the solution of metals by what he calls the electric acid. I have seen some of his electrats of silver, which are the most singular phænomenon I ever heard of. Besides other curious observations, Brugnatelli has confirmed the discovery of the chemical alteration of metals by the electric fluid. He has proved, by an exceedingly curious experiment, before made by Volta, that electricity decomposes water; that it seizes on the oxygen disengaged; and that, in this combination, it acquires the astonishing property of dissolving silver and reducing it to the saline state. This may be easily tried: nothing is necessary but to adjust to Volta's apparatus a silver conductor the two branches of which are each immersed in a glass of water. Scarcely is this communication established, when you will observe a multitude of small bubbles moving in a vortex around the branch of the conductor, which receives from the apparatus the electric fluid, while from the opposite branch there proceeds a cloud of a cylindric form, which descends to the bottom of the vessel. If the free gas, disengaged from the branch where the electric fluid enters, be collected, it will be found to be pure hydrogen: you will find also, by inspecting the branch immersed in the second vessel, that the silver has not only been dissolved, but that a large quantity of very brilliant dodecaedral crystals has been formed. If an arc of gold be substituted for the silver conductor, the branch which receives the electricity and the extremity where it issues will in like manner be covered with bubbles, and the aëriform fluid collected is detonating gas. The gold, however, has experienced no alteration. It is therefore evident that electricity acts as a powerful acid; it appears also to be susceptible of becoming oxygenated in the decomposition of water, of being strongly charged with the acidifying principle, and of afterwards extending its action to the metals, with which it produces peculiar salts. The

salts

ſalts already known, are the electrat of copper, which is of a beautiful green colour; the electrat of zinc, which is of a dark gray; that of iron, which has a reddiſh-yellow colour; and the beautiful electrat of ſilver, which cryſtalliſes in regular and exceedingly tranſparent dodecaedra. Theſe metallic electrats are inſoluble in water. They, however, can be carried in the electric current to a conſiderable diſtance, and cover other metals with their ſaline coating. Hitherto the electrat of ſilver is that which has exhibited the greateſt conſtancy and regularity in its cryſtalliſation: it depoſits itſelf on conductors of gold and ſilver, on glaſs, and other bodies with which it is in contact.

" Brugnatelli has endeavoured to determine the properties of theſe metallic cryſtals: he has found that they are inſipid, that they are inſoluble in water, and that they effloreſce in an atmoſphere of a high temperature. The nitric acid diſſolves them with a ſtrong effervefcence. The ſolution is limpid, but alkalies render it turbid and decompoſe it. There is precipitated from it an oxyd of ſilver, which can be attacked by all the acids. The gas diſengaged during the effervefcence has not yet been examined, but it is ſuppoſed to be of a peculiar nature.

" Gold and platina are not ſenſibly altered by the electric matter which paſſes through them; though it often happens that the electric current depoſits on gold a ſtratum of zinc, copper, mercury, or ſilver, according to whichever of theſe metallic bodies it traverſes.

" Some are diſpoſed to believe that the electric matter poſſeſſes the property of conveying at the ſame time two metals through a third body. If the tongue, indeed, be touched in two different points with different metals, two pieces of coin for example, one of gold and the other of ſilver; and if the upper edge of each of theſe pieces be brought into contact ſo as to form an arc, a ſtrong ſavour will be perceived; and the nature of this ſavour will be different according to the diverſity and combination of the metals; which evidently appears to indicate an aſſociation of the ſubſtances.

" To conclude: The diſcovery of Volta is ſtill in its infancy; as yet we have only a ſmall number of facts, and prudence

prudence seems to require that we should determine the general laws which the electric matter follows in its combination with oxygen before we attempt to form theories."

Respecting Volta's discovery, Mr. Göttling has published the following notice:

"The galvanic battery, constructed by professor Volta, with plates of silver and zinc, having bits of pasteboard, moistened with salt water, interposed between them, is, no doubt, worthy of the utmost attention. The decomposition of water; the decomposition of earthy and metallic salts; the production of acids and of fulminating silver; the decomposition of the sulphurous acid, which have already been effected by it; its action on alkalies and ammonia, &c. show how interesting this discovery is to chemists, and what important discoveries may be expected from it. There is reason, therefore, to wish that the researches on this subject may be multiplied and rendered more general. The plates of silver, however, necessary for this purpose, seem to be an obstacle; as the pieces of coin, commonly used, too soon lose their brilliancy, and cannot be procured in sufficient number by those who have time and opportunity to make the experiments. Copper, indeed, may be used instead of silver; but it soon becomes oxydated. I have therefore endeavoured to find some other metal to be used instead of silver; and of all those mixtures which I tried, that formed of one part of ferruginous antimony and two parts of lead, I found to be the most useful: that is, regulus of antimony, prepared with iron in the common way, is to be fused with lead in the above proportion. This mixture is exceedingly fusible, and may be formed into plates of the required size by being poured into moulds. The effects when this metal is employed are not so strong as with silver; and according to my experiments, 100 pairs of zinc plates and plates of this mixed metal are equal to 80 pairs of zinc and silver plates. This metal, however, is to be recommended on account of its cheapness, and because it is not easily oxydated. The mixture employed for printing-types produces nearly a similar effect."

Professor Göttling has published also the following notice

respecting

respecting a matter similar to manna, which he has found in preparing sugar from beets:

"If sugar," says he, "be extracted from dry beet-roots, according to my method *, and if more water be poured over the residuum, after standing a considerable time it will become very slimy. If the slimy water, which has no longer the least sweetness, be decanted from the remaining matter of the beets, and be evaporated in a glass or porcelain dish to the thickness of syrup, at a slow oven heat, it appears on cooling, or when it has stood some time in the open air, in the form of stellated crystals, which have a sweetish-sour and somewhat nauseous taste. If rectified spirit of wine be boiled over these crystals in a proper vessel, they in a great measure dissolve in it; but, in cooling, again separate themselves from the solution in white sharp-pointed crystals: a portion of uncrystallised slimy matter remains at the same time undissolved. The crystallised part, however, is far from being sugar; though when treated with nitrous acid it furnishes very pure oxalic acid, and, like sugar, is soluble in alcohol; but in regard to taste it has a great similarity to manna. It differs from sugar, in particular, by the following circumstances:—That concentrated sulphuric acid perfectly colourless is not rendered black by it: that by combustion it leaves a residuum of vegetable alkali, and is decomposed neither by the spiritous nor acid fermentation, nor by slow putrefaction. I am of opinion, therefore, that these crystals are to be considered as a peculiar component part of beets, not yet known, which exists in them in considerable quantity; and I think myself authorised to assert, that perfectly pure sugar cannot be obtained from beets when the roots are cut and the juice expressed, or when they are boiled with water, and the juice afterwards inspissated by boiling, because some of this component part will always be mixed with it. To be convinced of the presence of this substance the following method may be employed with most advantage:—When the beets are dried, and the sugar has been extracted, more water

* Professor Göttling's method consists chiefly in extracting the sugar from the dry beets by infusing them in cold water.

must

must be poured over the remaining parts of the beets. Or, a few beets also may be rasped, and the expressed juice may be brought to spiritous or rather acid fermentation in the usual way, that the sugar it contains may be decomposed. When the fermentation is over, pour off the clear liquid and evaporate it to dryness at a gentle heat; and heat over the residuum, in a retort or other convenient vessel, rectified spirit of wine till it begin to boil. Then decant the clear spiritous liquid, and deposit it in a cool place, where this component part will crystallise from it. To obtain the crystallised part perfectly free from spirit of wine, the latter may be made to evaporate in a gentle heat."

## MEDICINE.

The *Allgemeine Medizinische Annalen*, published at Altenburg, for the month of June 1800, contains the following article, in a letter dated from Brunswick:—" The secret remedy for the tape-worm, for the discovery of which M. Mathieu, formerly an apothecary at Berlin, received an annuity from the present king of Prussia, with the title of aulic counsellor, is as below:

I.

℞. *Limatur. Stanni Angl. pur. unc. unam.*
*Pulv. rad. filicis maris drachmas sex.*
——- *Semin. cynæ unciam dimidiam.*
——- *Radic. jalapp. resinosæ,*
——- *Salis polychresti ana drachmam unam.*
*Misc. Fiat cum mellis communis sufficiente quantitate electuarium.*

II.

℞. *Pulv. rad. jalapp. resinosæ,*
——- *Salis polychrest. ana scrupulos duos.*
——- *Scammonei Aleppensis scrupul. unum.*
——- *Gummi guttæ grana decem.*
*Misc. Fiat cum melle communi electuarium.*

" 1st, In employing this remedy for the tape-worm, it is essential to make the patient observe, during several days before, a strict regimen, and to use, above all, salted food, such as herrings, &c. as well as ſoups with bread, and light vegetables.

" 2d, In regard to the uſe of the medicine itſelf, a large tea ſpoonful of No. 1. muſt be given to the patient every two hours. This muſt be continued for two or three days until the patient feels the motion of the worm in the inteſtines.

" 3d, A large tea ſpoonful of No. 2. muſt then be given to the patient every two hours till the worm is evacuated. When the evacuation is too long in taking place, ſome ſpoonfuls of freſh caſtor oil may be given to the patient, and an injection of the ſame oil may be adminiſtered.

" 4th, As the age, ſex, and conſtitution of the patient may require a conſiderable difference in the application of the remedies and the quantity of the doſes, it will be indiſpenſably neceſſary that the direction and modification of the treatment ſhould be entruſted to a ſkilful phyſician.

" In the laſt place, it muſt be obſerved, that the efficacy of the firſt remedy will depend chiefly on the quality of the fern; and that it is abſolutely neceſſary to employ the root of the *filix mas*, and not that of any other. Care alſo muſt be taken to pulveriſe only the interior ſolid part; and that the powder obtained have a reddiſh colour."

The following caſe of the deleterious effects of opium remedied by the excitement of pain, has been publiſhed in the third volume of the American Medical Repoſitory, by Valentine Seaman, M. D.—" Having ſo frequently obſerved," ſays Dr. Seaman, " the great quantity of opium that a perſon, under the operation of acute pain, will take, without having any ſoporific effects induced by it, I have long been of the mind, that pain might be uſefully excited to remove the deadly influence of a large doſe that may have been previouſly taken.

" Yeſterday I had an opportunity of putting my principles to the teſt of experiment, being called to ſee a female patient who had, about two hours before, taken an ounce of laudanum, and then lay in a deadly ſtupor, from which all the efforts of her friends were inſufficient to awaken her. Attempts had been made to get ſome vinegar into her ſtomach, but, I believe, with little effect; nor did I ſucceed much

better

better in endeavouring to give her a dofe of white vitriol. I then procured a fmall fwitch, and applied it pretty freely to her arms and fhoulders, which were defended only by a thin linen covering. I alfo applied fome ftrokes to her legs. In the courfe of a very fhort time, indeed almoft immediately upon the application of this remedy, fhe roufed up, and begged me to defift. She continued, for a time, much confufed, with involuntary turns of laughter. Two fcruples of white vitriol were then adminiftered, followed, in about fifteen minutes, by half a dram of ipecacuanha; notwithftanding which, and alfo having her throat repeatedly tickled with an oiled feather, it was near an hour before fhe could be made to puke: however, finally, fhe puked, and, by the affiftance of frequent draughts of warm water, her ftomach was pretty thoroughly evacuated.

" By the affiftance of her friends fhe was kept awake, or, at leaft, flept but little at a time during the night, and this morning appears entirely recovered."

## VACCINE INOCULATION.

The Medical Committee for the Vaccine Inoculation at Paris has lately publifhed the following notice:

" The committee has juft inoculated fome cows with the vaccine matter. This experiment has fucceeded. The puftules appeared in the moft regular manner, and following the fame progrefs as in man. The committee will fpeedily publifh a detailed account of this noble experiment, which had been before tried at Rheims with full fuccefs. A great many medical men and curious perfons came to be convinced, by ocular demonftration, of the truth of this fact, fo interefting in the hiftory of the vaccine."

A memoir has been publifhed at Geneva on the vaccine inoculation by Dr. Oder, profeffor of medicine, in order to be fubmitted to the minifter of the interior, which, after giving an account of this important difcovery, and of the progrefs and nature of the difeafe, concludes with the following obfervations on the certainty of its being a preventative:—" We have acquired certain proof, in two ways,

 that

that the vaccine inoculation is a perfect security against the small-pox.

"1st, By the direct or indirect communication which all our inoculated patients had with a great number of children attacked with the small-pox in every quarter of the city. It is well known that the small-pox is infectious long after the patients are in a condition to go abroad. Van Swieten estimates that the disease is still capable of communicating itself sixty days after it has made its appearance; but most patients, after the twentieth day, go about as usual in the streets and public places, and wherever their business or occupations may lead them. It is impossible, therefore, that nearly four hundred children, inoculated for the vaccine four months ago, should have all escaped if they were susceptible of infection from an epidemic distemper so general as that which prevails here at present, and to which 150 children have fallen a sacrifice within our walls. None of them, however, have had the small-pox except four, who certainly had the germ of the disease before they were inoculated.

"2d, We have even inoculated the small-pox from arm to arm, and with all the precaution necessary to insure the success of the operation, on ten or twelve of those inoculated with the vaccine, and seven weeks after, the scars of the vaccine had dropped off; but none of them showed the least symptom of general infection. The incision became slightly inflamed; but it speedily dried up without areolæ, and without any appearance of fever.

"We have acquired also, by repeated trials, the most complete proof that the vaccine is not a contagious disease. In several families we have inoculated two, three, or four children after each other. Those who had the disease slept with some who had not been inoculated, and the latter were not affected till they were inoculated in their turn. In other respects we saw no instance of contagion.

"I shall add," says Dr. Oder, "that it did not appear to us that the inoculated vaccine was followed by any other malady; neither pimples nor eruption, neither sore eyes nor bad ears, nor any accumulations of matter so often observed after

after the ſmall-pox, both when inoculated and when the diſeaſe takes place in the natural way; on the contrary, we have inoculated ſeveral very delicate children, whoſe health ſeemed to be much improved by the operation in every reſpect.

*Extract of a Letter from Dr.* MARSHALL, *dated Valetta (Malta), January* 21, 1801.

" Since my laſt, I have the pleaſure to inform you that Dr. Walker and myſelf have been very ſucceſsful in purſuing the object of our miſſion. We have had the happineſs to arreſt the deſtroying progreſs of the ſmall-pox, which has raged very much, and has been very mortal at Minorca and Malta, and on board the fleet. The Minorqueens, who at firſt received the vaccine inoculation cautiouſly, are now very happy, and it is generally adopted among them. At Malta, the moſt complete ſucceſs has attended us. When we arrived here, we at firſt inoculated ſome children belonging to the Foundling Hoſpital, and from them ſeveral others; but, finding it difficult to perſuade the people of its efficacy, we ſubjected many of theſe to the teſt of the inſertion of the matter of the ſmall-pox, upon all of whom it had not the leaſt effect. This experiment was publicly made in preſence of the governor *, the Tuniſian ambaſſador, the Britiſh conſul, and many of the principal inhabitants. In going to the hoſpital we formed a proceſſion: the governor walked at our head in his uniform, the clergy in their canonicals; and we were accompanied by moſt of the medical profeſſors. The ſucceſs attending our experiment, and the publicity of the efficacy of the Jennerian inoculation, has cauſed the inhabitants to come in great numbers to be inoculated. The governor has had Dr. Jenner's work tranſlated and printed for the inhabitants, and he has alſo eſtabliſhed an hoſpital for the inoculation of the poor, under the name of the Jennerian Inſtitution; and as on our arrival we found the ſmall-pox in the iſland, the inhabitants have preſſed in crowds, both the maſs of the people and the nobility. Dr. Jenner's diſcovery is held here in ſuch high eſteem, that the governor, who is the idol of the Mal-

* The attendance of the Tuniſian ambaſſador was on account of a wiſh the dey had expreſſed to have the cow-pox introduced at Tunis.

teſe,

tefe, and for whofe welfare he is continually labouring, among other conciliating meafures, boafts of the fervice England renders them by the introduction of the cow-pox. He has alfo behaved to us in the moft kind and handfome manner, and has allotted to us, for our refidence during our ftay here, the moft beautiful palace of Valetta, heretofore the grand mafter's. The fmall-pox being very prevalent on board the fleet, it became neceffary, on account of its fhort ftay here, that one of us fhould accompany the expedition to complete the inoculation; and Dr. Walker's enterprifing fpirit could not reft till it was determined that he fhould go; and he has failed in the admiral's fhip.

"The following is the extract from the admiral's memorandum, in confequence of the fmall-pox raging in the Alexder and other veffels;

'Foudroyant, Malta, Dec. 9, 1800.

'The commander in chief thinks it neceffary to recommend to the refpective captains an immediate application to Dr. Marfhall and Dr. Walker, whofe excellent and fafe mode of treatment has been experienced on board the Foudroyant and other fhips in preventing the dreadful effects fo often attending the fmall-pox, but which may now be fo eafily avoided, without danger or inconvenience.

'By command of the admiral,

'W. YOUNG.'

"By a frigate which arrived here laft night, I learn that the fleet and army were on the 13th inft. in the bay of Marmoriffe; and Dr. Walker fends me word, that on board the fleet the fmall-pox feems now to be extinct; and that on the 10th of January he had inoculated the Corfican troops in the veffel where it had made its laft appearance. During his abfence, I have inoculated the troops left here under the command of general Pigot; and am occupied from morning to night in vifiting patients both in town and country. I hope foon to be joined by my colleague, and then we intend to fail for Palermo. It is extremely gratifying that the benevolent intentions of his royal highnefs the duke of York towards the army are fully anfwered by the attention we have received from the commanding officers at the garrifons of Gibraltar,

Gibraltar, Minorca, and Malta; and alſo from lord Keith and ſir Ralph Abercrombie in the expedition."

AGRICULTURE.

The Free Society of Agriculture, Arts, and Commerce, in the department of the Ardennes, has lately publiſhed a ſelect collection of memoirs; among which are: a paper on the cauſes of the ſmut in grain, and on the means of preventing it; on the cultivation of the fuller's thiſtle (*dipſacus fullonum*); on the culture of a kind of poppy; details on the turnip-rooted cabbage of Lapland, cultivated at Bouillon; and ſimple and eaſy means for preſerving grain from weevils and other inſects. Theſe means are as follows:—Immerſe ſome pieces of hemp cloth in water; wring them, and cover with them your heaps of grain: two hours after you will find the weevils adhering to the cloths; which muſt be carefully collected that the inſects may not eſcape. You may then dip them ſome time in water to drown them.

A plant of the hyoſcyamus placed in the middle of a heap of grain drives away theſe inſects: in that caſe you muſt watch, in order to cruſh them as they are endeavouring to eſcape; which will not require long time.

The laſt article of this collection is a recipe for a vegetative liquor proper for accelerating the blowing of bulbous-rooted flowers in winter in apartments. It is as follows:—Take nitrate of potaſh (nitre) three ounces; muriate of ſoda (common ſalt) one ounce; carbonate of potaſh (potaſh) half an ounce; ſugar half an ounce; rain water one pound: make the ſalts diſſolve in a gentle heat in a glazed earthen pot, and when the ſolution is completed, add the ſugar and filter the whole. Put about eight drops of this liquor into a glaſs jar filled with rain or river water. The jars muſt be kept always full, and the water muſt be renewed every ten or twelve days, adding each time a like quantity of the liquor: the flowers alſo muſt be placed on the corner of a chimney-piece where a fire is regularly made.

The ſame mixture may be employed for watering flowers in pots, or filling the diſhes on which they are placed, in order to keep the earth, or the bulbs and plants which they contain, in a ſtate of moiſture.

## DEATHS.

Lately at Nifmes, the place of his birth, the ex-jefuit Paulian, author of feveral works on the mathematics, at the age of 80. He was born of a proteftant family, and had never been ill in the courfe of his life. His works are: *Dictionnaire de Phyfique*, which went through feven editions in nine years, and which was long the only one ufed in the public fchools of France: it is a compilation not deftitute of merit, though inferior to that of Briffon. 2. *Traité de Paix entre Defcartes et Newton*, 3 vol. 3. *Commentaire fur La Caille et L'Hofpital.* 4. *Le veritable Syftême de la Nature oppofé au faux Syftême de la Nature.* 5. *La Phyfique mife à la Portée de tout le Monde*: two volumes only of this work were printed. 6. *Le Dictionnaire Philofopho-Theologique.* This work, deftined for the defence of the Chriftian religion, brought upon the author the hatred and farcafms of Voltaire. Father Paulian was a man of a mild difpofition: during the revolution he always behaved with great circumfpection in the exercife of the priefthood, to which he devoted himfelf. He was a member of the academies of Nifmes and Lyons. He has left fome unpublifhed works among them: *Memoire fur le Poids des Montagnes*, and one on Monfters.

On the night between the 12th and 13th of February, at the age of 78, in confequence of a violent pain and fpafms in his ftomach, which feem to have been the confequence of a gouty metaftafis, the celebrated French chemift Darcet, a learned phyfician, member of the National Inftitute and feveral other Societies, and profeffor of chemiftry in the *College de France.* Darcet diftinguifhed himfelf by various ufeful labours and refearches: experiments on earths and the manufacture of pottery and porcelain, which he greatly contributed to improve in France; refearches refpecting the action of fire, long continued and equally maintained; on the conftruction and combuftion of the diamond; the analyfis of animal matters, feveral mineral waters, and a great many ores.

## XXIV. *Account of the Life and Writings of* Olof Torbern Bergman, *Professor of Chemistry at Upsal.*

This celebrated chemist, the son of a collector of the king's taxes, was born at Catharinaberg, in West Gothland, on the 9th of March 1735. At an early period he showed a great deal of spirit and vivacity, which approached almost to giddiness; but, by application to study under a private tutor and at the school of Skara, this youthful fervor gradually subsided. At the age of 17 he was sent to the university of Upsal, where he first applied, in consequence of the natural bent of his genius, to mathematics and various branches of philosophy, which he studied with unremitting diligence, though one of his relations, under whose care he had been placed, often represented to him that these were pursuits not likely to procure him a livelihood. As he was obliged to obtain instruction in these sciences merely from books, and often employed whole days in study, shut up in his chamber from morning till night, his health was considerably impaired; and in order that he might restore it he made a tour to the country to see his parents, during which he amused himself with the study of natural history. When at the school of Skara he had been initiated in botany and entomology, particularly the latter, to which he applied with so much zeal that he formed a system of insects according to their state of larva, which was so well arranged that it could not have been considered as the work of a youth of eighteen. It is to be regretted that his other occupations prevented him from pursuing this subject further, and that only the classes of the larvæ were engraved and published. De Geer and Linnæus were both sensible of the value of his knowledge in this respect; and the latter, to show his esteem for him, gave the name of Bergman to a sort of phalæna. During this time, however, he did not neglect his favourite pursuit, and studied Palmquist's algebra, so difficult to be understood without assistance.



Phil. Mag. No. XXXV.
*April* 1801.

At the end of fifteen months he returned to Upfal, and in 1755 gave a proof of the progrefs he had made in mathematics and philofophy by a difputation *De Crepufculis*. Soon after he tranfmitted to the Royal Academy of Stockholm two differtations; one of them, *De Cocco Aquatico*, and the other *De Hirudinibus*; which were much approved by Linnæus, though he entertained an opinion on thefe fubjects different from that of the author. He defended alfo a difputation on aftronomical intercalation, in confequence of which he got the degree of doctor in 1758; and by another difputation on general attraction he obtained leave to become a private teacher of philofophy. Having improved himfelf in practical aftronomy at the obfervatory of Upfal, he affifted in obferving the tranfit of Venus in 1761, and was rewarded for his diligence and application by being made affiftant profeffor of mathematics and philofophy.

He fent different papers to the Royal Academy of Stockholm; one of which was on the rainbow, another on the *aurora borealis*, and a third on the twilight. The northern lights and electricity attracted his particular attention, and he at length laid before the Royal Society of Upfal a feries of obfervations which he had made on thefe fubjects during the courfe of four years, together with a variety of information collected by learned men both in Sweden and in other countries. His obfervations on electricity were fo much approved, that an extract from them was inferted in the Philofophical Tranfactions by Dr. Wilfon. The fame work contains his letters on the electric nature of turmalin, which nearly put an end to the difpute between Dr. Wilfon and Æpinus.

In the year 1763 he obtained a prize from the Royal Academy of Stockholm for an anfwer to the queftion, How thofe caterpillars which deftroy the leaves of fruit-trees can be extirpated? and two years after a double prize for fome new obfervations on the fame fubject. He was fo zealous for the intereft of the Academy of Stockholm that he fent it forty-one papers, each of which contained either fome new obfervations, or illuftrated and explained what had been known before. The Academy were fo fenfible of his fervices that in the year 1777 they allowed him an annual salary of 150 rix-dollars from their funds in order to defray the expense to which he was exposed by his experiments. Though most of his time was occupied with natural philosophy he still retained his taste for entomology: he discovered a new sort of gall-apple in the bark of the oak; wrote a dissertation on the saw-fly, *tenthredo*; on the worms so pernicious to the pine-fir; and, towards the latter part of his life, he wrote on the care and management of bees.

In the year 1758, in conjunction with some of his friends, he had established a cosmographical society, who undertook to give a description of the earth. The physical part was allotted to Bergman; and when it appeared in 1766, it was so well received that the whole edition was sold in the course of half a year: the work was soon after translated into German, Danish, French, and other languages. A second edition, much enlarged, appeared in 1773 under the title of A Physical Description of the Earth. In this work Bergman displayed a greater knowledge of mineralogy and chemistry than was expected; and his reputation as a chemist was still further increased by a dissertation on the method of preparing alum, which he published afterwards. In consequence of the last-mentioned work he was appointed professor of chemistry in 1767. About this period, in consequence of a proposal which he made, a new laboratory, models, various kinds of apparatus, and a new house for the professor, were provided. Under such circumstances it is not to be wondered at that, besides his young countrymen, pupils from distant parts should be anxious to repair to Upsal, that they might profit by the instruction of a man who had acquired so much celebrity.

His pupils admired not only his zeal and diligence in communicating instruction and in making experiments, but the wonderful perspicuity with which he explained the most difficult subjects. Bergman, however, did not confine himself to oral instruction: he enlightened the world by his writings; and his first attempt this way was Scheffer's Chemical Lectures, which he arranged, and enriched with valuable observations. His next publication was an Introduction to Chemistry; and this was followed by his Sciagraphia of the

Mineral Kingdom; which appeared alſo in French under the following title: *Manuel de Mineralogiſte, &c. traduit et augmenté par Monges le Jeune*; Paris 1784; 8vo. Bergman endeavoured alſo, by examining a variety of ſubſtances with unremitted diligence, to enlarge chemical knowledge; and the reſult of his experiments, which he communicated to the public in various papers, was, for the moſt part, afterwards collected by himſelf and publiſhed in three volumes, with the title of *Opuſcula Phyſica et Chemica plerumque antea ſeorſum edita, jam ab Auctore collecta et aucta*; Holmiæ 1779. 8vo. A new edition of this work was publiſhed under the inſpection of the celebrated profeſſor Leſke at Leipſic; and, after Bergman's death, profeſſor Hebenſtreit added three more volumes of his detached pieces, and publiſhed the whole with the title of *Bergmanni Opuſcula Phyſica et Chemica, pleraque ſeorſum antea edita, nunc collecta et reviſa. Vol. VI. cum Indice locupletiſſimo et Tab. Æn. Editionis Curam poſt Auctoris Mortem geſſit E. B. G. Hebenſtreit*; Lipſiæ 1788—1790. 8vo. An Italian tranſlation of Bergman's phyſical and chemical works was publiſhed by ſubſcription at Florence under the title of *Opuſcoli Chimici e Fiſici di T. Bergman*; Florence 1790, Tom. III. 8vo. The third volume of this tranſlation contains conſiderable additions by Dolomieu, which form nearly one-half of it.

Though it would be impoſſible, in the ſpace allotted for this ſketch, to give a detailed account of all Bergman's diſcoveries and the improvements he made in chemiſtry, by which he acquired ſo much reputation, we cannot omit enumerating ſome of them. He explained, in the moſt ſatisfactory manner, why an alum ley, without any addition, does not cryſtalliſe; and ſhowed that this phænomenon aroſe from its containing an exceſs of acid. He rejected the common addition, and inſtead of it uſed pure argil, which, without doing any hurt, increaſes the quantity of the alum. He firſt ſhowed that fixed air is a real peculiar acid, which is not indebted for its properties to the ſubſtances employed for extracting it. He conſidered it as the principal component part of mineral waters, and gave a moſt ingenious method of decompoſing them; which is a proceſs exceedingly difficult.

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He ſhowed alſo how to imitate them by art, and prepared different kinds, which had a perfect reſemblance to thoſe of Seltz, Spa, Pyrmont, and other places. By a careful analyſis of the hot waters he was led to an equally ſucceſsful method of imitating them alſo. In a word, we are indebted to him alone for the great improvement which has been made in the analyſis of mineral waters, and the art of aſcertaining their real component parts. He was the firſt who gave a proper account of the properties of the newly diſcovered acid of ſugar, and its mode of union with other bodies. He not only explained, in the cleareſt manner, the nature of cobalt, nickel, and platina; but declared, many years before the diſcovery was acknowledged, that manganeſe, molybdena, and tungſten, muſt contain peculiar ſemi-metals; and this conjecture was afterwards fully confirmed by the experiments of the ableſt chemiſts. He was the firſt alſo who gave a proper account of the properties of manganeſe and of its regulus. He diſcovered the cauſe of the phoſphoric quality of blende in the ſparry fluor with which it is mixed. He was the firſt who diſcovered ſulphurated tin. His examination of iron is a maſterpiece, and to him we are indebted for our knowledge of the cauſe of the brittleneſs of cold ſhort and red ſhort iron. He taught a moſt excellent proceſs for analyſing ores with the blow-pipe by the addition of different ſaline ſubſtances, and an ingenious method of analyſing ores in the wet way. The diſcovery of this laſt method, before unknown, gave riſe to a great many others, and in all probability will produce more. Such are the important diſcoveries which he made in regard to the nature and properties of bodies; he was fully ſenſible that 30,000 experiments would be neceſſary to bring them to perfection, and he clearly ſaw that more time would be required for this purpoſe than he could hope to command, even if his life ſhould be prolonged to a more diſtant period than he had reaſon to expect; but he opened the path and pointed out the way which his followers ought to purſue.

The cauſes which enabled this eminent man to make ſuch progreſs in chemiſtry were, beſides great ingenuity and indefatigable application, his extenſive knowledge in natural

hiſtory,

history, natural philofophy and mathematics, which he applied to his favourite fcience. He introduced mathematical accuracy into chemiftry, and, by his example, induced others to call in the aid of calculation to give more precifion to their refults. Analyfis enabled him to examine the component parts of bodies, and by fubjecting thefe parts to calculation he could determine the quantities with more accuracy and truth.

To him is modern chemiftry indebted for many of thofe luminous facts which ferve to fupport it; and it may be afferted, without taking from the merit of thofe who eftablifhed the new fyftem, that the fpirit of accuracy and patient inveftigation, introduced in a great meafure by Bergman, has tended not a little to give folidity and beauty to the edifice.

His writings are all diftinguifhed by great order, perfpicuity, and neatnefs of language. The moft celebrated of the learned focieties in Europe; thofe of London, Stockholm, and Göttingen; the Academies of Dijon and Turin, the Medical Society at Paris, the Society of the Searchers into Nature at Berlin, and the Imperial Academy of the Searchers into Nature, all chofe him a member of their different bodies. He was made a member alfo of the Academy of Montpellier after he had gained the double prize, for a paper on the diftinguifhing marks of thofe kinds of earth which are moft ufeful in agriculture. The Royal Academy of Sciences at Paris, which admitted only eight foreign members, made choice of Bergman to be one of that number. The Royal Academy of Berlin invited him to that city in 1776; and on his declining this offer, the king of Sweden, who foon after his coronation in 1772 had raifed him to be one of the firft twenty-eight knights of the order of Vafa, made a confiderable addition to his income. The ftudents of the province of Finland caufed a medal, of ten ducats value, to be ftruck as a teftimony of their efteem and refpect for his talents; on the one fide of which was a good likenefs of him, with the infcription: *Torb. Bergman Patriæ Decus, ac Decus Ævi*; on the reverfe, *Ephoro egregio Natio Fennica, die 1 Maii* M.DCC.LXXXIV.

When it is confidered that Bergman was of a weak conftitution, ſtitution, and that his labours were often interrupted by his bodily infirmities, it will appear rather ſurpriſing that he ſhould have been able to accompliſh ſo much. He was frequently tormented with the head-ache, and ſuffered alſo conſiderably from the hæmorrhoids. Finding his health declining he repaired to Medwi, to have the benefit of the waters there, from which he had often before experienced relief; but a few days after his arrival he was ſeized with convulſions, which attacked him ſeveral times, and expired on the 8th of July 1784. All the company then at the baths attended his funeral. He left a widow, by whom he had two children, who died young; and from her the king purchaſed his library and apparatus for the uſe of the chemical profeſſor, giving her a handſome penſion as a compenſation for them.

Bergman's character and diſpoſition were well calculated to conciliate reſpect and eſteem. He was far from being moroſe, or an enemy to innocent mirth. Whenever he thought he could gratify his friends, he was always ready to participate in their amuſements. He never appeared obſtinate or ſupercilious in delivering his opinions: if they were thought dubious, he explained them; but, if he found ſufficient reaſon, he retracted them. This candid and magnanimous conduct he diſplayed alſo as a writer; but, when fully convinced of the truth and ſolidity of any point, he adhered to it with unſhaken firmneſs. However ardently attached to his favourite ſciences, he never deſpiſed other knowledge, or rejected any thing with the utility of which he was unacquainted; on the contrary, he valued and promoted every thing that had the leaſt tendency to enlarge human knowledge. A ſtranger to vanity, he never ſolicited for worldly honours or dignities; and thoſe which were offered to him he uſed as a philoſopher ought.

Towards his friends his heart was ever open and warm. When aſked advice, he gave it with readineſs and ſincerity; and his benevolence never ſtood in need of being ſolicited. His intimacy with Scheele is well known: he was the firſt perſon who called the attention of the Swediſh nation and of foreigners to the talents of that eminent man; and it is very probable that, had he not been introduced into notice by

Bergman,

Bergman, the world would have been deprived of the greater part of his important discoveries. The many literary friends Bergman had in all nations, are a testimony of the esteem in which he was universally held; and his letters not only show how capable he was of maintaining a literary correspondence, but that he possessed a feeling heart. For the sacred writings he always entertained the utmost reverence; he made them the constant rule of his actions; and if any one in his company attempted either openly or indirectly to attack them, or to question their divine origin, he defended them with a warmth which on other occasions he seldom manifested.

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## XXV. *History of the Art of Dyeing, from the earliest Ages.* *By* J. N. Bischoff *.

However useful and laudable may be the exertions of those who trace back the various steps by which the arts have risen from infancy to a state of improvement, and who endeavour to throw light on the periods of their invention, and to explain the means and accidental circumstanoes by which they have been brought to perfection, it must be allowed that this task is attended with great difficulty as well as uncertainty. Such inventions, in general, have had so rude an origin, that mankind did not think them worth their attention till they had attained to a certain degree of perfection. This difficulty seems in particular to occur in regard to the origin of dyeing, as it appears to be much anterior to the oldest of the antient writers with which we are acquainted. Every thing, therefore, that can be said on the subject must be founded on conjecture.

In my opinion the origin of dyeing may be ascribed to that natural vanity inherent in human nature, and which inspires mankind with a desire to please, and to distinguish themselves above others. The effects produced by the juice of certain plants or berries when bruised, by the rain on different kinds of earth, or by the blood of animals applied to cloth, sug-

* From *Versuche einer geschichte der Färberkunst.*

gested,

gefted, in all probability, the firft idea of this art; and the above fubftances were, no doubt, the firft dye-ftuffs with which the inventors ornamented their clothing made of fkins. When thefe appeared among their neighbours with their parti-coloured garments, a fpirit of imitation would naturally be excited among the latter; and this paffion would induce them to find out better dye-ftuffs; fuch as, by imitating the bluenefs of the fky, or the beautiful tints of birds and flowers, might enable them to outfhine thofe who had preceded them in this new art.

But it would foon be obferved that this beauty was of fhort duration, and that it was neceffary to renew the tints by a frefh application of the colouring fubftances. The many experiments which mankind might eafily make while they lived under the freedom of the early ages, and perhaps fome fortunate accident, may have at length taught them how the colours could be fixed, by preparing their fkins with falts and other fubftances of the like kind.

As mankind began to multiply, new wants were created, employments were increafed, and thofe devoted to the fervice of religion began to be diftinguifhed by a certain kind of drefs from the other claffes of fociety. Hence arofe particular ranks and conditions, to which certain diftinguifhing marks were affigned according to their functions; and for this purpofe no better or more certain means could be found than diverfity of colours. In the earlieft ages, therefore, particular colours were allotted to the leaders of armies, judges, and priefts; and for feftivals, funerals, and religious ceremonies.

Mankind would now begin to confider dyeing as an art not merely calculated to gratify vanity or to give pleafure to the eye, but as an invention of the utmoft utility to fociety. No longer contented with the dye-ftuffs furnifhed by vegetables and land animals, they began to fearch even the ocean, with which they were become more familiar, and difcovered a fubftance proper for dyeing purple,—the firft colour refpecting the origin of which we find any certain information in the monuments of antiquity. Almoft all thofe antient authors who fpeak of this invention, afcribe it to love and a

 fhepherd's

ſhepherd's dog. The dog happening to take in his mouth a ſhell-fiſh which he found lying on the ſand, his mouth became coloured with the purple juice it emitted. The ſhepherd's ſweetheart having ſeen this colour, was ſo ſtruck with it, that ſhe requeſted her lover to procure her a dreſs dyed with it. In conſequence of this requeſt the ſhepherd endeavoured to find out the ſubſtance which had produced ſuch a beautiful colour, and by theſe means diſcovered the art of dyeing purple *. Some, however, aſcribe this invention to a Tyrian named Hercules, who preſented the reſult of his firſt experiment to the king of Phœnicia, who was ſo captivated with it, that he made purple one of his principal ornaments †. The laſt opinion appears to be the more probable, as the former fable may have originated from a play on words; for, as *dog* and *colour* are expreſſed in the Syrian language by the ſame word ‡, the Greek writers, who borrowed this ſtory from the Syrians, and the Romans who copied the Greeks, might eaſily have been led into an error.

That a Tyrian was the inventor of purple, is unanimouſly aſſerted by all writers; but they differ in regard to the time. Some place the invention under Phœnix, the tenth king of Tyre, that is, about 1500 years before the birth of Chriſt §; others, in the time when Minos reigned in Crete, or about the year 1439 before the Chriſtian æra ||. The period of the invention, however, can be better determined than that of the art of preparing the colour; though the diſſertations written by old as well as new authors on this ſubject are ſo numerous that they would almoſt form a ſmall library. For the ſatisfaction of the reader, I ſhall here give an abſtract of what has been ſaid by theſe authors reſpecting a colour which for-

* Caſſiodorus, lib. I. Var. Ep. ii. Jul. Pollux, lib. i. 4. Achilles Tatius de Amor. Leuc. et Clitoph. lib. ii. Ruph. Volaterrani Commentar. Urban. lib. xxvii.

† Goguet de l'Origine des Lois, des Arts, et des Sciences, book ii. chap. 2.

‡ Bochart de Animal. p. iv. lib. v. cap. 11. Braun de Veſtitu Sacerdot. Hebræorum, cap. 14.

§ Phœnix was the ſon of Agenor and brother of Cadmus: the latter came to Greece in the year 1519 before Chriſt.

|| Goguet ut ſupra.

merly

merly was held in so much estimation; which is mentioned so often by profane as well as sacred writers; which still makes a figure in our poetry, or which is so often used as a figure in common life, and which many are acquainted with only by name.

The substance employed for dyeing this expensive colour was the liquor of a kind of shell-fish called by the Hebrews *argaman*, by the Greeks πορφυρα, and by the Romans *purpura, murex*, and *ostrum*. It has been often described, and the shell of it may often be seen in collections of natural curiosities. There were two kinds of this shell-fish, both of which were employed in dyeing purple. One of them, from its figure, was called *buccinum*. The other was the purple shell-fish properly so called (*purpura, pelagium*), and consisted of several kinds, some of which were fitter than others for dyeing†. The best were found in the neighbourhood of Tyre, on the coast of Gætulia, and near Lacedemon. It is described by Pliny in the following manner‡:

"The purple shell-fish has a conical shell surrounded with a seven-fold row of prickles which proceed to the mouth, through which the animal can project its tongue. The latter is as long as the finger, and so hard that it can penetrate the shells of other fish and nourish itself on their substance. This also affords an easy method of catching it. The fishermen take a net with wide meshes, into which, instead of bait, a few muscles are put. As soon as these are immersed in the water they again become fresh, and when the purple fish observe that they open their shells they thrust their tongue into them; but scarcely do the muscles perceive this when they again shut their shells, and in that manner they are caught.

"In fresh water these shell-fish soon die; but they can live fifty days on their own saliva. In the spring they emit a sort

* Michaëlis used to observe in his lectures, that this word formerly signified a funeral monument.

† Plinius, Hist. Nat. lib. ix. c. 36.

‡ A more circumstantial account may be found in the following scarce works: *Fabii Columnæ Lyncæi Purpura cum fig. æn.* Romæ 1616. 4to.; and *G. Gotlob Richter Progr. de Purpuræ antiquo et novo Pigmento. Gott.* 1741. 4to.

of white ſlimy matter, and at that period they no longer produce purple: they muſt therefore be caught before that time or after the dog-days *."

The animal itſelf conſiſts of three parts; between the two firſt is found the valuable liquor, to the quantity of a few drops, in a white receptacle. This liquor the animal emits with its life, and is loſt when it dies ſlowly †. They are therefore caught alive, and killed by a blow ‡. When a ſufficient quantity of the liquor has been obtained, a little ſalt is added to it, and it is ſuffered to ſtand three days. The maſs muſt then be boiled a certain time in a leaden veſſel over a ſlow fire, and the fleſhy particles which float at the top muſt from time to time be ſcummed off. It is then kept for ten days, after which the colour is tried on a bit of pure wool, and the colour is boiled till it no longer appears red, but has a blueiſh caſt.

Thus far the proceſs for preparing the liquor ſeems to have been the ſame among all the antient nations. But in the operation for dyeing there appears to have been ſome difference. The Jews immerſed the wool in lime-water before it was dyed, and then waſhed it in a ley §.

I am of opinion that among other nations the wool was ſubjected to a ſort of boiling, and that the antient authors have omitted to mention this circumſtance, as well as other proceſſes, merely becauſe they were things univerſally known. At any rate, the firſt ground of the colour was given to the wool by means of a kind of ſea-weed (*fucus marinus*), and then it was dyed. Hence the colour acquired the name of *fucus* ‖. Alkanet (*anchuſa*) was alſo employed to lay a foundation for the purple ¶.

* Pliny, lib. ix. c. 38.

† Ibid. c. 36. Ariſtotle, v. 5.

‡ This, in my opinion, may ſerve to explain a paſſage in Homer's Iliad, book v. ver. 83. where it is ſaid of a perſon killed in battle, "His eyes were cloſed by purple death;" that is to ſay, "the death of the purple ſhell-fiſh;" a ſpeedy death. A like paſſage is found in the Æneid, book ix. v. 349., which may be explained in the ſame manner.

§ Braun de Veſtitu Sacerdotum Hebræorum, p. 261.

‖ Pliny, c. xxvi. 10.

¶ Ibid. c. xxii. 17.

The

The Tyrians gave the firſt ground of their purple dye by the unprepared liquor of the *purpura*, and then improved or heightened it by the liquor of the *buccinum*. In this manner they prepared their double dyed purple *, *purpura dibapha*, which was ſo called either becauſe it was immerſed in two different liquors, or becauſe it was firſt dyed in the wool and then in the yarn.

The Greeks, according to the account of a certain Democritus, poured the liquor as it came from the fire into a veſſel, immerſed the wool in it, and ſuffered it to remain in that ſtate a day and a night. Between this method and that of the Romans there ſeems to be no eſſential difference. The latter, according to Pliny, ſuffered the wool to remain in the liquor five hours, after which they dried it; they then immerſed it in the liquor again, and continued in this manner till it had imbibed all the dye. The liquor of the *buccinum* alone gave a falſe dye; it was therefore neceſſary to fix it by the liquor of the *purpura* in order to render it durable.

To fifty pounds of wool two hundred of the liquor of the *buccinum*, and a hundred and ten of that of the *purpura* †, were employed. By theſe means the wool acquired a colour like that of the amethyſt, and thence it had its name.

The colour called *conchylium* ‡ was dyed almoſt in the ſame manner, only that none of the liquor of the *buccinum* was employed; that half as much of the liquor of the *purpura* was uſed as in the former caſe: and that, beſides this, it was mixed with one half urine and water. This colour, therefore, was brighter and cheaper than the other §.

Theſe are all the different methods of dyeing purple among the antients. But beſides theſe the antients were acquainted alſo with the method of dyeing with kermes (*cuſculium*, *graines d'ecarlate*)

* Pliny, lib. ix. c. 17.

† In Pliny's time, 100 pounds of the liquor of the pelagium or of the purpura could be purchaſed for 50 denarii, about 1 *l.* 10 *s.* The liquor of the buccinum was double that price.—See Pliny, lib. ix. c. 40.

‡ This colour was alſo called *hyacinthus*, *cæruleus*; the Jews gave it the name of *thecbelet*, from which *conchylium* is ſaid to be derived. The ſhell-fiſh which furniſhed the dye was called *chilzon*. See *Braun*, i. 12.

§ Latter writers conſider, but improperly, theſe two colours to be the ſame.

*d'ecarlate*) a ſcarlet colour *, called in the Bible *tholaat ſchani* (*colorem coccineum*), which they held in high eſtimation †. Whether the ſcarlet of the antients was the ſame as ours, cannot be eaſily determined, but we are told by Pliny that it was a very agreeable roſe colour.

All theſe dyes, the preparation of which I have here deſcribed, are frequently confounded by antient authors, who often give the name of purple to all red colours ‡; and from this circumſtance, and from that of various other colours being produced by the mixture of the before-mentioned four kinds of dye, the confuſion and uncertainty which prevails on this ſubject have, in my opinion, ariſen. But this uncertainty might perhaps be in ſome meaſure removed by making the following diſtinction. The purple colours of the antients were:

### I. *Simple Purple Colours.*

1ſt, The Tyrian § or twice dyed purple, *purpura Tyria dibapha*; becauſe, as above ſaid, it was neceſſary that the cloth or wool ſhould be immerſed in two different liquors. This was the purple properly ſo called. The colour was a dark red, like that of curdled blood; but it ſhone with moſt ſplendour when one looked at the cloth from the bottom up-

* Whether this be the ſcarlet mentioned in Geneſis, xxxviii. 27—30, I cannot determine. It is thus tranſlated in the Septuagint.

† I ſhall have occaſion to ſpeak further of this dye-ſtuff; I ſhall here only obſerve that the Romans procured their kermes chiefly from Galatia, the African provinces, and Luſitania.

‡ It was in general a proverbial mode of expreſſion among the antients, when they wiſhed to deſcribe any thing red, to compare it to the Tyrian dye. Frequent inſtances of this may be found in the Greek and Latin dramatic writers. See Le Clerc's Biblioth. Choiſie, tom. xx. p. 186—194. We are told by Ælian that the Lacedemonians uſed purple clothes in war to prevent the blood from being ſeen: but from the impoſſibility of giving purple dreſſes to a whole army, on account of the dearneſs of that colour, Ælian, no doubt, alludes to ſome cheaper kind of red dye.—*Var. Hiſt.* lib. xvii. chap. 6.

§ This dye was not diſtinguiſhed by the above name merely on account of its being prepared by the Tyrians, but becauſe theſe people obtained the beſt purple ſhell-fiſh from the neighbouring ſea, and becauſe they underſtood beſt, according to the teſtimony of all antient authors, the art of dyeing it.

wards *, as our dyers do when they examine whether a colour be genuine or not.

Besides Tyre there were other places celebrated either on account of their purple shell-fish or their method of preparing the dye. The following are often mentioned in the works of the antients :

The *Gætulian purple*, for which the shell-fish found on the Gætulian coast were employed. A great deal of cloth, &c. was dyed in particular in the island of Madura and Porto Sancto, which on that account were by the antients called the Purple Islands (*Insulæ Purpurinæ* †).

The Lacedemonian ‡.

The Tarentine. This had somewhat brighter shades §.

At first these kinds of purple were exceedingly rare at Rome, but under Augustus they became the fashionable colours; though a pound of purple wool could not be procured for less than a thousand denarii, somewhat more than 32*l.* sterling. The almost incredible prices at which this purple was sold among the antients, is to be understood, in general, as applicable to these kinds, as the others were much cheaper.

2d, Amethyst colour (*color amethystinus*), the preparation of which I have described as above. It was not such a dark red as the first kind, but inclined somewhat to blue, like the colour of the precious stone from which it takes its name. This colour also had its different shades, according to which it was called sometimes *color janthinus* ||, and sometimes *fuccinus* ¶.

3d, Hyacinth colour (*color conchylius, hyacinthus, cœruleus*). In the Bible this colour is called *thechelet*, from which the Latin word *conchylium* is said to be derived. As this colour did not require so much purple liquor, it was not so dear as the former colours; and in the time of Julius Cæsar a pound of it cost only 100 denarii, 5*l.* sterling. It, however, was

* Seneca Natur. Quest. i. 5. † Pliny, vi. 32.
‡ Pliny, xxi. 8. § Ibid. ix. 39.
|| From ἴα, a kind of violet, which had an appearance similar to this colour
¶ L. 70. Digest. de Legatione.

not dark red, but had a blueiſh caſt *. Pliny mentions three ſhades of it, one of which he compares to the night-violet, *viola ſerotina*.

II. *Compound Purple Colours.*

1ſt, *Color Tyriamethyſtus.* This was a mixture of the Tyrian purple with the amethyſt colour, as the name indicates.

2d, *Color hyſginus* † was compoſed of the ſcarlet and Tyrian purple colours.

Theſe are the colours which, in the works of the antients, are particularly diſtinguiſhed by the name of purple. As no ſpecimens of them have been preſerved, we muſt be contented with the deſcriptions given of them by Pliny and others; and it would be fruitleſs to attempt to obtain a more accurate knowledge of them ‡.

Of their durability, Plutarch gives a remarkable inſtance in the life of Alexander. This prince, it is ſaid, found in the treaſury of the Perſian monarch a large quantity of purple, 180 years old, which ſtill retained all its beauty; and the cauſe, according to Plutarch, was, that it had been prepared with honey.

As the antients had no colour equal to the purple in beauty, durability, and coſtlineſs §, it is not ſurpriſing that they en-

* For this reaſon it was called *color dilutus*, *ablutus*, and, at laſt, *blutus*, of which the French have made *bleu*, the Engliſh *blue*, and the Germans *blau* —*Braun ut ſupra*, c. xiii. *Claud. Salmaſ. ad Tertullian de Pallio*, p. 189.

† Pliny, lib. ix. c. 41. deduces this name from a certain flower which had a ſimilar colour.

‡ It is here neceſſary to notice ſome terms of art reſpecting this colour, which often render the meaning of the antient authors obſcure. The purple liquor was called *flos*, *ros*, *ſanies*, *virus*; when prepared for dyeing, *pigmentum*, *medicamen*, *jus*, in Greek βαμμα ξεμα. Liquor not yet ready for dyeing was called *rudia medicamenta*, *immatura et viridis cordina*; a perfect dark red Tyrian colour was diſtinguiſhed by the appellation of *color preſſus*, *ſaturus*, *ſaturatus*, *oneratus*, *plenus*, *adſtrictus*, *auſterus*, *ſuperbus*, *vegetus*; a bright fiery red colour *color exoneratus*, *excitatus*, *clarus*, *acutus*, *vigidus*, *dilutus*, *ablutus*, *blutus*.

§ See Plato de Repub. lib. iv. p. 449. edit. Lugd.

The learned tranſlator, Marſilius Ficinus, has rendered this paſſage ſo confuſed, that without the help of the Greek text it is not poſſible to underſtand it. Thus, for example, he tranſlates the word βαφευς, which ſignifies a dyer, by *fullo*.

nobled

nobled it by the particular purpofes to which it was deftined. In the earlieft periods, and immediately after its invention, it was confidered as the favourite colour of the gods. Nay, the Deity himfelf feems to have conformed to the weaknefs and ideas of man by choofing it to be the moft diftinguifhed ornament of his houfe and his minifters *.

As the power and refpect of kings increafed, it was made a fymbol of majefty †; and this was carried fo far, that in the time of the emperors it was confidered as a particular right belonging to the princes of the imperial houfe; fo that immediately after their birth they were wrapped in purple fwaddling-clothes, and by thefe means obtained, as it were, a title to the empire. Nay, it was confidered as an almoft indifpenfable ceremony in the choice of an emperor ‡ that the fuccefsful candidate fhould be clothed in purple; and we have inftances of the foldiers, when nothing elfe was at hand, tearing the purple from their ftandards and wrapping it round the newly chofen emperor.

In free republican ftates this colour was a mark of the higheft official dignity. Thus the fupreme magiftrates at Rome were diftinguifhed by broader or narrower purple ftripes (*lati et angufti clavi*), with which their clothes were bordered behind and before. Hence it happened that purple, which every one had been before at liberty to ufe, was by the emperors made a regality; and when affumed by private perfons, or when a piece of purple was applied to another colour, this crime was punifhed with death as a kind of high treafon §.

* Exodus, xxvi. 1. xxviii. 5, 6, 8. xxxviii. 18. xxxix. 8. Luther tranflates the word *thecbelet* very improperly, yellow filk, which properly is fky blue, or hyacinth colour, and a kind of purple, as I have already obferved

† Hence purple is called *facer murex* in the Laws, Tit. c. de Veftib. holober. et Intinctione facri Muricis; and hence the expreffion *adorare purpuram*, lib. iv. c. de Conful.—See G. Pancirollus de Rebus deperditis, p. i. tit. 46. c. Commentar. Salmuth.

‡ Conftantine VII. a Greek emperor of the tenth century, from this ceremony got the title of *Porphyrogennetes*; that is, born in purple.

§ This is mentioned, for the firft time, refpecting Nero, in the life of that emperor, by Suetonius. *Vita Neronis*, c. 32. L. i. c. Quæ res venire non poff. L. iii. c. de Veftib. holoberis.

In every province, and particularly in Phœnicia, there were certain houfes for dyeing purple belonging to the emperors, and each of thefe was under the infpection of an overfeer (*procurator baphiorum*), whofe chief bufinefs was to take care that the articles were well dyed. Thefe overfeers were alfo under the infpection of a *comes facrarum largitionum* *. Neither the dyers nor their children durft follow any other occupation, but formed a peculiar tribe and had their own fymbol, which was a fmall bafket containing purple wool †.

Though the art of dyeing purple was fo highly efteemed and fo much practifed, it was at length forgotten in the weft and afterwards in the eaft, fo that the learned confider it as now totally loft; while others doubt whether fuch a colour ever exifted, and whether it was poffible to prepare it from the liquor of a fhell-fifh ‡. But thefe opinions are evidently refuted by the unanimous teftimony of antient authors, and particularly by the experiments and attempts which have been made by the moderns to revive this art.

Thomas Gage fpeaks of a fhell-fifh of this kind found in the neighbourhood of Nicoya, a fmall Spanifh town in South America, which has all the properties of the purple fhell-fifh defcribed by Pliny and other antient authors. The Spaniards dyed with it Segovian cloth, which coft twenty crowns *per* ell.

About the year 1686, a Mr. Cole difcovered on the coaft of Somerfetfhire a fhell-fifh of the like kind §. Plumier alfo found at the Antilles the fame fpecies, which he calls *piffeurs*, becaufe they can fpirt the fea water from them to a great diftance ‖.

* We have an account of nine places of this kind for dyeing purple: 1ft, Calabria; 2d, Dalmatia; 3d, Iftria; 4th, Sicily; 5th, Africa; 6th, Tripoli; 7th, Gallia; 8th, The Balearian iflands; 9th, Gallia Narbonenfis. —See *Guid. Pancirollus Notitia Imperii*, lib. ii. 39.

† Zano, in his Lettere dell' Agricultura, lett. i. p. 57. fpeaks of a tombftone with the infcription *M. Tullio Purpurario.* Gruter has inferted three of the fame kind in his collection.

‡ For example, Jacobfon in his Schauplatz der Zeugmanufacturen in Deutfchland, vol. i. part 10.

§ Philofophical Tranfactions for 1685, No. 197. *Acta Eruditorum* for 1686, p. 620.

‖ Leipzeger Sammlungen for the year 1746, p. 274.

Moft

Moft of the experiments in regard to this purple were made by Reaumur * and Du Hamel †. The latter found a *buccinum* on the coaft of Poitou; but in particular, certain balls fhaped like an egg, which he calls *purple eggs*, and which contained a yellowifh liquor. This liquor, when dropped on a piece of linen, gave it a pale yellow colour; but in a few minutes, to his great aftonifhment, it changed to all the fhades of yellow, green, and fky-blue, till it at length was converted into purple. The experiment muft be made in the open air; and Du Hamel obferves that the fun-beams contribute a great deal to the durability and darknefs of the colour.

That this great influence of the fun-beams on the purple was not unknown to the antients, is proved by the account left us of this colour by a Greek female author ‡, and which, in all probability, firft induced the above writers to undertake their experiments. As the paffage which contains this information §, and which was pointed out to me by a friend, deferves to be better known, I fhall here fubjoin the following tranflation of it:

" The Phœnicians at prefent (in the 11th century) catch this animal (the purple fhell-fifh) in the following manner, and give with it, to wool, fuch a beautiful colour that the deceived eye miftakes it for flowers.

" They form a ftrong rope, of confiderable length, made of twifted rufhes, faftened together with knots, fo as that they can let it down into the fea. To this rope they attach bafkets made of rufhes or reeds plaited through each other. Thefe

* Memoires de l'Acad. des Sciences for 1711, p. 181.

† Ibid. for the year 1736, p. 49.

‡ Eudocia Macrembolitiffa, a daughter of the Greek emperor Conftantine VIII. who lived about the end of the tenth century. Her book, which is called Ιωνια, contains very interefting information refpecting celebrated perfons of every condition, with other things worthy of notice. It was preferved in manufcript in the king's library at Paris, but intended for publication.—See *Anfelm. Bandurius Not. ad Antiq. Polit.* p. 818; *Fabricii Bib. Græca*, vol. vi. p. 715; *I. Ch. Wolf Fragmenta Mulierum Græcarum*, p. 30; and Catalog. Feminarum olim illuft. under the head *Eudocia*.

§ Du Frefne has inferted it in the appendix to his *Gloffarium* under the word κογχυλευτα.

baſkets have ſpikes at the mouth; for the points of the ruſhes or reeds all run towards each other inwardly, ſo that, when looked at from without, the entrance ſeems eaſy, but when the fiſh have got into it they cannot return *. Theſe baſkets the fiſhermen let down to the rocks, faſtening to the upper end of the rope a piece of cork that it may float; and in this manner they are left night and day, and when the baſket is drawn up it is found to be full of the purple ſhell-fiſh. The animals are then cut in pieces, and when freed from dirt are ſalted; after which they are thrown into a kettle over the fire. When heated the blood ſeparates itſelf, becomes fluid, and begins to throw up ſcum; a part of it turns red and another blue, and another aſſumes ſome other colour. If a piece of cloth be now put into this liquor, it acquires the ſame colour after it is thoroughly impregnated with it.

" The purple colour does not acquire all its brilliancy till it has been expoſed to the ſun; for the rays of that luminary give it more brightneſs, and render the colour darker; and its ſplendour, by the celeſtial fire, is brought to the greateſt perfection."

This paſſage, combined with the neweſt diſcoveries and a little practice, might eaſily enable us to prepare purple as beautiful as that of the antients. But the perfection to which other dyes have been brought, and the dye-ſtuffs diſcovered in modern times, render this method of dyeing unneceſſary.

One might almoſt be induced to believe that the antients had no other colours beſides purple; but the contrary is proved by the whole hiſtory of antiquity. Nay, it is probable that they had other colours before purple, only they were either not ſo durable or ſo pleaſing to the eye, and therefore the antient writers did not think it worth their while to ſay any thing reſpecting them.

The Greeks, about the period of Alexander the Great, and under his ſucceſſors, firſt began to render black, dark blue, yellow, and green dyes, &c. more beautiful, and to learn the art of fixing them on linen †. We find, however, among

* This is exactly the form of ſome baſkets made at preſent for catching fiſh.

† See Pliny, lib. xix. c. 1. Zano, Lettere dell' Agricult. tom. iii. p. 2. let. 6. p. 253. Chambers's Univerſal Dictionary, under the head Dyeing.

the

the various companies established by Numa at Rome, a dyers' company, *collegium tinctorum*; but these I consider to have been at first purple dyers*. Afterwards the art of dyeing continued to increase among the Romans, and they began to divide colours into general (*principales*) and particular (*minus principales*), according as they were usual among both sexes, or were exclusively worn by either †. Thus the antient authors frequently speak of the colours by which the four different parties (*factiones*) at the Circensian games were distinguished from each other, and which, on that account, were called the *colores circenses*. These were green (*color prasinus*), aurora colour (*russatus*), ash colour (*venetus* ‡), and white §.

But the art of dyeing was not confined merely to the Phœnicians, Hebrews, Greeks, and Romans; it was soon communicated to other nations, each of which employed for this purpose such minerals and plants as their different countries produced. According to the account of Pliny ‖ and other authors, the Gauls who inhabited beyond the Alps dyed the most beautiful purple and other colours with herbs; but they were not acquainted with a method of fixing them. We are

* Plutarch in the Life of Numa.

† Thus, for example, yellow was commonly used as the colour of the veils (*flammea*) worn by brides on the day of their nuptials, and peculiar to the female sex alone.—*Pliny*, lib. xxi. c. 8.

‡ This, in particular, was the colour of the clothing of mariners and of the sails of ships.

§ This colour afforded employment in particular to the *fullones*, who washed and scoured white as well as coloured clothing. For this purpose they employed urine, chalk, saltpetre, and fumigation with sulphur. The processes to be used were prescribed by a peculiar law (*Lex Metellana*) issued by the tribune Metellus in the year 354 after the building of the city. They were required, in the first place, to wash the clothes with Sardinian earth, then to expose them to the vapour of sulphur, and to scour them with unadulterated Cimolian earth, (from *Cimolus*, one of the islands called the *Sporades*,) which restored the splendour of the colour that had been destroyed by the sulphur. In the last place, they smoothed the pile of the cloth with the skin of a hedge-hog or the fuller's thistle (*carduus fullonius*), and then pressed it. A passage in the gospel according to St. Mark, c. ix. ver. 3, alludes to this process. Luther translates the word γναφευς (*fullo*) improperly by making it signify a *dyer*.—See *Pliny*, xxxv. 17, and *Schwartzenii Antiquitat. Fullonicæ*.

‖ Lib. xxii. cap. 2.

told

told also by Tacitus that the German women manufactured linen dresses, and dyed them of a beautiful purple red colour. Some, however, assert that these dyes were communicated to the cloth merely by dipping it in the blood of men or of animals. But this opinion is evidently erroneous; as it is impossible that cloth could acquire a good colour by being dipped in blood; and because it is highly probable that the Germans would learn from their neighbours the Gauls, with whom they had so much intercourse, their art of dyeing, which is so highly celebrated by Pliny.

This writer gives us a very obscure description of an ingenious mode of dyeing, which has a near resemblance to our cotton and flannel printing, practised by the Egyptians. They applied to the white cloth certain tinctures more or less capable of imbibing the dyes (*colorem sorbentibus medicamentis*), and which were not visible. The cloth was then put into a boiler containing the dye or colouring composition (*cortina pigmenti ferventis*), and after it was taken out it appeared as if painted with various colours. These colours never faded; and the cloth, by the boiling, was rendered more durable *.

Something of the same kind is related by Herodotus, who informs us, that certain people, who lived near the Caspian sea, by means of the leaves of trees, which they bruised and steeped in water, could form on cloth the figures of animals, flowers, &c. which were as lasting as the cloth itself †.

The art of dyeing was also in great esteem among the Persians at an early period. Nay, the Persian dyers, notwithstanding their being Mahometans, have chosen Christ as their patron; for they have a tradition among them which says that he was of that profession ‡. On this account they call a dye-house at present Christ's work-shop §. Among

* Pliny, xxxv. 11.

† The same thing is still practised by the savages in Chili with the juice of certain plants, which contain also saponaceous matter.—See *Goguet*, vol. ii. b. 2. c. 2.

‡ Sike, *Not. ad Evang. Infantiæ Salvatoris*, p. 55, relates this tradition in the following manner:—Christ being put apprentice to a dyer, his master desired him to dye some pieces of cloth of different colours; Christ put them all into a boiler, and when the dyer took them out he was terribly frightened on finding that each had its proper colour.

§ Angeli de la Brosse *Lexicon Persicum*, under the head *Tinctoria ars.*



the

the Chinese, Hoang-ti, one of their earliest emperors, was the first who wore a blue dress, as being the colour of the heavens, and a yellow one, as being the colour of the earth *. He also caused dresses of different colours to be made in imitation of flowers and birds, that they might serve as marks of distinction to the high and the low, the rich and the poor, in his empire †.

More instances which show that the art of dyeing was held in high esteem at an early period among other nations, might easily be collected from antient history; but what has been said is sufficient to prove the great antiquity of it, and how soon it was spread almost over the whole inhabited part of the globe.

Though it might be of great utility, and enable us to extend and improve the art of dyeing as practised at present, if we could procure a complete account of all the methods and ingredients employed by the antient dyers, the information left us by the antients on this subject is exceedingly defective and obscure: for their philosophers and historians did not think it worth their while to give a minute description of things which were generally known in their time; and besides this, they were too proud to condescend to visit tradesmen for the purpose of making themselves acquainted with the processes which they followed in their different arts ‡. Even Pliny deserves reprehension on account of this mistaken pride when he says: "I should have described the art of dyeing, had it been included among the number of the liberal arts §."

As further information, therefore, is not to be obtained, I shall lay before the reader the following catalogue of dye-

* Martini, Histoire de la Chine, liv. i. p. 42.

† Goguet, Origine des Loix, vol. iii. p. 336.

‡ Of all the antient philosophers none seems to have entertained more just ideas on this subject than Socrates, who thought that the hand of the artist ought to be guided by the eye of philosophy, and for this reason often carried his scholars to the workshops to see the different processes used in them. Some pleasing instances of this may be found in Xenophon's Memorabilia.

§ Pliny, lib. xxii. 2.

stuffs

ſtuffs uſed by the antients, beſides the purple ſhell-fiſh already mentioned:

1. *Alumen*, alum. Pliny calls it an earthy ſalt, *ſalſugo terræ*. Some of it was white, and ſome blackiſh. The former was uſed for bright, the latter for dark colours *. It muſt not, however, be confounded with our alum, for the antients were not acquainted with the art of lixiviating ſalts and making them cryſtalliſe. This art was invented in the twelfth century in the eaſt, and therefore the antients comprehended under the name of ſalts all ſaline bodies which they found in diſtricts impregnated with ſalts †.

2. *Anchuſa*, alkanet. It was uſed for giving the ground to thoſe ſtuffs which were to be dyed purpliſh red ‡. The ladies among the antients employed it, according to Suidas, as a paint.

3. The blood of birds was uſed by the Jews §.

4. *Coccum*, kermes. Thoſe obtained from Galatia and Armenia were conſidered by the antients as the beſt; the next were thoſe brought from the Aſiatic provinces; the worſt were the Spaniſh ‖.

5. Oak-leaves ¶.

6. The *fucus marinus* (a kind of ſea-weed). The Cretan was the beſt; it was generally uſed for the ground of good colours, and therefore the Romans afterwards gave the name of *fucus* ** to all colours whatever. It was uſed alſo as a paint by the ladies.

7. *Geniſta*, dyer's broom, was alſo known to the antients ††.

8. *Hyacinthus*, the violet. The Gauls prepared from it a dye which produced a colour ſimilar to the *hyſginum*, before deſcribed ‡‡.

* Pliny, xxxv. 15.

† See *Beckman Comment. de Hiſtoria Aluminis* in the *Commentat. novæ Societat. Reg. Gotting.* for the year 1778, p. 111.

‡ Pliny, xxii. 20.

§ Braun de Veſt. Sacerdotum, p. 280.

‖ Dioſcorides, iv. 48.

¶ Pliny, lib. xiii. 15.

** Ibid. xxvi. 10. xxxii. 6.

†† Ibid. xvi. 18.

‡‡ Ibid. xxi. 26.

9. *Lotos*

9. *Lotos medicago arborea.* The rind was uſed for dyeing ſkins, but the root for dyeing wool *.

10. The bark of the walnut-tree and the green huſks of walnuts. The dyeing quality of theſe would ſoon be diſcovered from the effect they produced on the hands †.

11. Madder, *rubia erythrodanus.* The antients were early acquainted with this ſubſtance ‡; but whether it was the ſame with the root known at preſent by that name is doubtful.

12. Woad, *glaſtum*, called alſo *vitrum* from its glaſſy-like colour. Among the Gauls, according to Pliny, the ladies, on days of feſtivity, dyed their whole bodies with it, which gave them the appearance of Moors. The Britons alſo, before they engaged in battle, painted themſelves with it, that they might have a more terrible appearance §. That the plant was then known is certain; but whether the antients were acquainted with the art of preparing it as we do at preſent ſeems dubious. I ſhall have occaſion hereafter to give a more complete deſcription of it.

This ſhort account of the art of dyeing among the antients is, in my opinion, worthy of notice, as it is neceſſary for illuſtrating various paſſages both in the ſacred and profane writers which have puzzled many of the commentators becauſe they were unacquainted with the art. It muſt afford ſome ſatisfaction alſo to modern dyers to read an account of the ſtate of their art among the antients, and may perhaps induce ſome of them to make further reſearches on the ſubject, and to enrich dyeing with ſome new diſcovery.

[To be continued.]

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## XXVI. *Letter from Dr.* MOYES *to Dr.* GARTHSHORE, *containing an Account of ſome intereſting Experiments with M.* VOLTA'S *Galvanic Pile. Communicated by Dr.* GARTHSHORE.

Dear Sir,

HAVING lately improved my galvanic apparatus, and having, with Mr. Nicol's aſſiſtance, tried by its means ſome

* Pliny, lib. xvi. 30. † Ibid. xv. 22. ‡ Ibid xix. 4. xxiv 11.
§ Ibid. xix 3. xxi. 26; Cæſar de Bello Gallico, 5; Pomponius Mela, iii. 6.

 experiments

experiments alluded to in my former communication, I ſhall now, in compliance with your obliging requeſt, ſtate to you briefly ſuch of the reſults as ſeem to me moſt deſerving of notice.

1ſt. When two gold wires, connected with the extremities of a galvanic column containing 400 ſquare inches of zinc and 400 of copper, were inſerted into the legs of an inverted glaſs ſyphon 2-10ths of an inch in diameter and containing thirty grains of diſtilled water, the water in one leg gave oxygen gas, and that in the other hydrogen gas, without any apparent diminution of rapidity during a period of 24 hours.

2d. When the wires were inſerted into two glaſs tubes cloſed at bottom with double bladders, each tube containing twenty grains of diſtilled water, and partially immerſed in a glaſs of water; the water in the one tube gave oxygen gas, and that in the other gave hydrogen gas, without any apparent diminution of rapidity as long as the experiment was continued, which was ſometimes upwards of a whole day: but when the quantity of water in each tube exceeded not in weight ſeven or eight grains, the production of gas ſoon began to be ſenſibly retarded, and in nine or ten hours totally ceaſed, though the water in the tubes during the proceſs had loſt but a ſmall proportion of its bulk; and the power of the column, which was carefully examined from time to time, ſuſtained no perceptible degree of diminution.

3d. When the wires were inſerted into the legs of an inverted glaſs ſyphon containing a ſolution of white arſenic, the fluid contained in one of the legs, namely, in that which was connected with the leaſt oxydable extremity of the column, acquired, in the ſpace of an hour and a half, the power of reddening the tincture of turnſol; a fact which was expected without any trial by our ingenious friend Mr. James Wood.

4th. When the ſyphon was filled with a purple infuſion of red cabbage, every thing elſe remaining the ſame, the liquor or fluid in one leg ſoon became red, and that in the other as ſoon became green.

5th. When the wires were inſerted into two glaſs tubes, cloſed at bottom with double bladders, each tube containing

twenty

twenty grains of a purple infusion of red cabbage, and partially immersed in the same kind of fluid, the fluid in one tube soon became red, and that in the other as soon became green, whilst the colour of the fluid into which the tubes were immersed sustained no perceptible change.

6th. When the galvanic column was placed under an exhausted receiver, its power of giving shocks was almost entirely suspended; but it detached from water also in the receiver both oxygen and hydrogen with a degree of vivacity remarkably greater than that which it exhibited when the whole was placed in the open air.

7th. When the column was placed without the receiver, and the water on which it acted was placed within, the evolution of gas was seemingly the same as it was when both were within the receiver; and in either case the evolution of gas was accelerated and retarded in a striking degree by diminishing and increasing the atmospherical pressure.

8th. When a communication was made between the extremities of a powerful galvanic column containing 800 square inches of metal, a sound like that of a small electrical spark was distinctly heard, and a flash was as distinctly seen every time a communication was made, even in the full light of the day.

9th. When the above column was at the height of its strength, its sparks were seen in the light of the day even when taken with a piece of charcoal held in the hand, the body forming the rest of the circuit; yet neither extremity of this powerful machine discovered any tendency to attract or repel the lightest bodies which were placed in its vicinity. Its shocks were greater than a man could well bear. It maintained its power with little diminution for more than a period of eight days, yet it moved not perceptibly a fine linen thread which was attracted by a small piece of sealing-wax at the distance of more than three inches.

From these and other analogous experiments, which were repeated, I think, with sufficient attention, we may draw, I presume, the following conclusions:—1st, That no quantity of pure water can ever be totally changed into gas by any known action of the galvanic influence. 2d, That the weight of the gafes which any given quantity of water can yield to any known action of the galvanic influence, muft ever bear but a fmall proportion to the weight of all the water employed. 3d, That two veffels filled with water may be fo expofed to the galvanic influence, that one of them fhall yield hydrogen gas and it only, whilft the other fhall yield oxygen gas and it only. 4th, That, by help of the galvanic influence, we can extract at pleafure either hydrogen or oxygen from one and the fame quantity of water. 5th, That, ftrictly fpeaking, water is not decompofed by furnifhing gas to the galvanic influence; it giving no oxygen where it furnifhes hydrogen, and no hydrogen where it furnifhes oxygen. 6th, That the proportion fubfifting between the elements or component principles of water may be fenfibly changed by the galvanic influence. 7th, That, if the properties of compounds be more or lefs changed by every change in the proportions of their principles, the properties of water may be more or lefs changed by a proper application of the galvanic power. 8th, That water, after being duly expofed for a proper length of time to the galvanic influence, muft certainly deferve a medical inquiry, as in all probability it will have medical powers different from thofe of ordinary water. 9th, That hydrogen and oxygen, at the moment of their galvanic feparation from water, are peculiarly difpofed to a ftate of combination. 10th, That, at the moment of their galvanic feparation from water, both hydrogen and oxygen are difpofed to combine with atmofpherical azot; the one to produce the volatile alkali, and the other the nitrous or nitric acid. 11th, That the galvanic feparation of oxygen and hydrogen from water under an exhaufted receiver, is probably accelerated by two caufes, a great diminution of atmofpherical azot, and a great diminution of atmofpherical preffure. 12th, That, when a galvanic column is placed under an exhaufted receiver, its power of communicating fhocks is almoft entirely fufpended; probably in confequence of the extremely attenuated fluid furrounding it being a better conductor of the galvanic influence than the fentient parts of the

6 animal

animal frame: and laftly, That, if the galvanic influence in fome of its properties be apparently analogous to the electrical fluid, it differs from it in others in a ftriking degree.

Thefe, Sir, are fome of the pofitions which the foregoing experiments appear to fupport. If they fhall happen to afford you any entertainment, you may probably receive another fupply; and I hope to be alfo, at fome future period, able to afford you fome account of fome trials of the galvanic influence in the cure and mitigation of various difeafes. The galvanic influence, as you very well know, happily admits of an eafy application to any part of the human body. It may fteadily be applied for any length of time, with very little labour on the part of the operator, and with lefs inconvenience on that of the patient. Its action may be eafily increafed or diminifhed. It may be rendered, at pleafure, perceptible or not, as the indications of cure may happen to require; and I have lately contrived a piece of apparatus by which a fucceffion of galvanic fhocks, weak or ftrong, as the cafe may require, may be given to any part for any length of time at the rate of ten or twenty *per* fecond.

I am, with great efteem and regard,
Dear Sir,
Your very much obliged and faithful fervant,
H. MOYES.

Edinburgh,
1ft February 1801.

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XXVII. *Account of Experiments made in Germany with* VOLTA'S *Galvanic Apparatus. Communicated to the French National Inftitute by Dr.* FRULANDER *of Berlin**.

THE firft account of Volta's galvanic apparatus was communicated to Sir Jofeph Banks on the 2d of March 1800, and the firft experiments made in England were undertaken by Meffrs. Carlifle and Nicholfon, who, by its means, decompofed water; they alfo reddened tincture of turnfol, and precipitated metallic folutions in acids. Mr. Cruickfhank, of

* From the *Journal de Phyfique*, Pluviofe, an. 9.

of Woolwich, published in Nicholson's Journal, that he had formed the arbor Dianæ, and had reason to believe that he had produced an acid and an alkali. Mr. Henry, of Manchester, said he had decomposed ammonia and fixed alkali, and had found that air was not a good conductor of galvanism. This is all the information that had reached us in Germany through the medium of the French papers, and particularly the Physical Annals, published by Gilbert.

M. Richter, well known in Germany by his *Beiträge zur nahern kentniss der Galvanismus*, saw the first notice of it in the Brussels Journal, and had made the greater part of the discoveries above mentioned when he received it. The following is a brief account of what he had discovered up to the 30th of September 1800.

*Exp. I.* A zinc wire applied to the eye, and communicating with a piece of some other metal, touched by the moistened finger to form the galvanic chain, exhibits to the eye looking towards the column a blue colour, which becomes reddish when the finger is removed. The eye must be a little accustomed to this experiment before it can be fully sensible of the effect; the phænomenon then becomes constant.

*Exp. II.* A frog, galvanised in the usual manner, which at the end of half an hour exhibited no more movement, still showed some after five hours and a half when Volta's apparatus was employed.

*Exp. III.* Gold, the flame of a taper, heated glass, and rarefied air, are conductors of galvanism almost in the same manner as they are of electricity: they cannot therefore be employed to insulate.

*Exp. IV.* When two metal wires are brought together in a glass tube, formed almost as in the galvanometer of C. Robertson, no effect is produced. The case is the same when removed too far from each other. See Plate V. fig. 1.

*Exp. V.* Tin, lead, iron, copper, or bismuth, placed at *a* and *b*, exhibit different degrees of galvanic force proportioned to the degrees of the oxydability of the bodies employed. Mercury and silver produce the same effect. Gold experiences no oxydation.

*Exp.*

*Exp. VI.* By employing gold on both ſides M. Richter obſerved that there were formed bubbles of air ariſing from the two wires. He obſerved alſo that the air-bubbles which aroſe from one of the wires were larger than thoſe from the other; and he thence concluded that the ſpecific gravity of the one kind of air muſt be greater than that of the other.

*Exp. VII.* M. Richter endeavoured to ſeparate the two airs, and for that purpoſe invented the apparatus repreſented by fig. 2. He introduced two gold wires into a marble veſſel filled with water, and applied the zinc at *a* and the ſilver at *b*; the wire *a* was about an inch diſtant from the wire *b*. He cloſed the chain, and found, after ſixteen hours, that the bell *s*, which he had ſuſpended over *a*, contained one part of air; while the bell *w*, ſuſpended over *b*, contained two and a half.

By putting phoſphorus into the air *s*, he ſaw vapours formed, which became more abundant in proportion as the operation advanced, and the volume of air at the end of ſix or eight hours was diminiſhed. There remained only about a third part: it is not impoſſible that a portion of azotic gas was diſengaged from the water during the experiment.

The air in *w*, which occupied about a cubic inch, being inflamed as it paſſed in large bubbles into the atmoſphere, detonated with the ſame force as a mixture of equal parts of hydrogen and atmoſpheric air.

M. Richter had placed two glaſſes, *a* and *z*, below the wires: that placed under *b* contained ſome metallic parts, ariſing, in all probability, from a little copper contained in the gold.

The two gaſes when placed together produced water, as uſual, on an electric ſpark being made to paſs through them.

*Exp. VIII.* By employing on the ſide *b*, zinc, tin, copper, charcoal, and plumbago, M. Richter always obtained hydrogen, provided the wire brought into contact with the zinc of the apparatus was of ſuch a nature as not to become oxydated. He employed alſo, inſtead of gold, charcoal, plumbago, and cryſtalliſed oxyd of manganeſe at *a* and *b*: the phænomena were always the ſame as well as when he placed platina at *a*, keeping the gold, charcoal, plumbago, and oxyd of manganeſe at *b*.

*Exp.*

*Exp. IX.* The effect is ſtronger as the wires approach, but without touching each other; and particularly if the wires are of zinc. It is of leſs ſtrength with gold, and weakeſt with oxyd of mangaueſe.

The high temperature of the water alſo contributes to ſtrengthen it.

*Exp. X.* M. Richter obſerving that the effects took place even when the wires were far removed from each other, he did not think it probable that a particle of water at the one wire, ſo far diſtant from the other, would give hydrogen when oxygen is produced at the other wire. He therefore aſked himſelf whether it was really the ſame drop of water that furniſhed the conſtituent parts, or whether the water was not rather the conductor of the galvanic fluid, which produced the different gaſes by a peculiar compoſition. He endeavoured, therefore, to ſeparate the two wires by a body different from water. Fig. 3. ſhows how this was accompliſhed.

He filled two tubes with water, and formed a communication between them by means of a gold wire, *c*: the two wires at the extremities, *a* and *b*, were alſo of gold. He employed in the two ſides the zinc and ſilver of his battery; and, putting his apparatus into action, found afterwards in each of his tubes oxygen and hydrogen gas, produced in the ſame manner as if there had been only one tube.

*Exp. XI.* M. Richter then endeavoured to find a body which might ſerve as a conductor of the galvanic matter without decompoſing it. He found none among the ſolid bodies, as gold had produced the decompoſition of the water. He employed ſpirit of wine and ſulphuric æther: they produced no air, but were good conductors. He then took concentrated alkaline ſolutions, which were better conductors, but produced gaſes. M. Richter at length found that colourleſs concentrated ſulphuric acid gave no gas, though a good conductor. Fig. 4 and 5 ſhow in what manner he employed it. The two glaſs tubes, combined in the form of a V, being half filled with acid, he made water to flow gently down the ſides of the glaſs upon the ſulphuric acid until the tubes were filled; and this ſucceeded ſo well, that the fluids did not mix, ſince a bit of paper, tinged with tincture

ture of turnſol, did not become red when placed very near the acid in the water. The wires *c* and *d* were of gold; *a* the zinc, and *b* the ſilver, of the apparatus; when brought into contact he received in the tube next the zinc oxygen gas, and in that towards the ſilver, hydrogen gas.

*Exp. XII.* He obtained the ſame reſult by ſeparating the two tubes: ſee fig. 6. The two tubes were filled half with acid and half with water, and one of the gold wires was in the acid and the other in the water. Theſe two wires immerſed in the acid communicated with a third wire, and the other two with the zinc and ſilver of the battery. When the apparatus began to operate, oxygen gas was ſeen to riſe in the one tube, and hydrogen gas in the other.

To produce a contrary effect, nothing was neceſſary but to turn the zinc towards *a*.

*Exp. XIII.* M. Richter combined ſeveral tubes in this manner. (Fig. 6.) All the wires which produced oxygen were in the water, and all thoſe which produced hydrogen in the acid. The wires in the water in contact with the zinc of the battery gave immediately oxygen gas; and when the zinc was applied on the contrary ſide they gave hydrogen gas.

Such are the experiments, from which M. Richter concludes that the two airs cannot be conſidered as conſtituent parts of water, but as two matters produced by a part of the water combined with the galvanic fluid, and that the generation of one is in no manner dependent on the production of the other.

*Exp. XIV.* M. Richter filled the tube of fig. 1. with nitric acid mixed with water: he employed two wires of different metals, *p e*, being of copper. The metal began to be diſſolved; but, when he brought the tube into contact with his galvanic battery in ſuch a manner that they formed a chain, the wire of zinc towards *a* diſſolved much ſooner; whereas that of copper towards *b* ceaſed to be diſſolved.

*Exp. XV.* M. Richter filled the tube with a ſolution of copper in ſulphuric acid. The two wires were of iron. The precipitation was as uſual; but when he brought the tube into the galvanic chain the precipitation was increaſed towards *a*, while it decreaſed towards the ſilver.

By putting copper wires into the ſolution every thing remained

mained as usual; but, when he exposed it to galvanism, the wire *a* began to be oxydated, while the wire at *b* precipitated the copper from its solution. The wires *a* and *b* being of silver, and the tube filled with a solution of silver in nitrous acid, the effect was the same. The same thing took place in a solution of zinc in the muriatic acid when the wires *a* and *b* were of zinc.

*Exp. XVI.* The same effect is produced if the affinity of the bodies dissolved is greater for the acid than that of the wire immersed in it.

The wires *a* and *b* were of copper, and the tube contained a solution of zinc; *a* and *b* were of silver, put into a solution of copper or zinc; *a* and *b* were of gold, put into a solution of zinc.

In all these cases there was a precipitation at *b*, and an oxydation at *a*. It was not necessary that the wires should be of different metals. The law was always constant.

Such is the series of phænomena observed by M. Richter. The celebrity he has so justly acquired gives reason to think that these experiments have been made with exactness. If the commission appointed by the Institute to pursue this labour examines and confirms them, it is to be expected that they will produce changes in the laws of affinity.

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## XXVIII. *An Account of the Petroleum Wells in the Burmha Dominions: extracted from the Journal of a Voyage from Ranghong up the River Erai-Wuddey to Amarapoorah, the present Capital of the Burmha Empire. By Captain* HIRAM COX, *Resident at Ranghong**.

*Saturday, Jan.* 7, 1797.

WIND easterly, sharp and cold, thick fog on the river until after sun-rise, when it evaporated as usual, but soon after collected again, and continued so dense till half past eight A. M. that we could barely see the length of the boat.

Thermometer at sun-rise 52°, at noon 74°, in the evening 69°; general course of the river north 20° west, main breadth from one mile to a mile and a half, current about two miles and a half per hour.

* From the *Asiatic Researches*, Vol. VI.

East

Eaſt bank, high, rugged, barren downs, with precipitous cliffs towards the river, of free-ſtone intermixed with ſtrata of quartz, martial ore, and red ochre; beach moderately ſhelving, covered with fragments of quartz, ſilex, petrifactions, and red ochre, and with rocky points projecting from it into the river.

Weſtern bank, a range of low ſandy iſlands, covered with a luxuriant growth of reeds. Theſe at preſent narrow the ſtream to three quarters, and in ſome places to half a mile, but are overflowed in the rains: the main bank rather low and ſandy, ſubject to be overflowed, its whole breadth about three miles to the foot of a range of low woody hills, which in point of vegetation form an agreeable contraſt to the eaſtern ſhore: theſe hills are bounded to the weſtward, at the diſtance of about twenty miles from the river, by an extenſive range of high mountains clothed with wood to their ſummits.

At half paſt ten A. M. came to the lower town of Rainanghong; a temple in it of the antique Hindoo ſtyle of building.

At noon came to the centre town of Rainanghong (literally, the town through which flows a river of earth oil), ſituated on the eaſt bank of the river, in latitude 20° 26′ north, and longitude 94° 45′ 54″ eaſt of Greenwich. Halted to examine the wells of petroleum.

The town has but a mean appearance, and ſeveral of its temples, of which there are great numbers, falling to ruins: the inhabitants, however, are well dreſſed, many of them with gold ſpiral ear ornaments, and are undoubtedly rich, from the great profit they derive from their oil wells, as will be ſeen below.

At two P. M. I ſet off from my boat, accompanied by the *mewthaghee*, or zemindar of the diſtrict, and ſeveral of the merchant proprietors, to view the wells. Our road led to the eaſt-north-eaſt, through dry beds of looſe ſand in the water courſes, and over rugged arid downs and hillocks of the ſame ſoil as deſcribed above; the growth on them conſiſting of ſcattered plants of *euphorbium*, the caſſia tree, which yields the *terra japonica*, commonly called *cutch* or *cut*, and uſed throughout India as a component part of a *beera* of *paun*, alſo a very durable timber for lining the oil wells; and laſtly the hardy *biar* or wild plum, common in Hindoſtan.

The ſky was cloudleſs, ſo that the ſun ſhone on us with undiminiſhed force; and being alſo unwell, I walked ſlowly; and as we were an hour walking to the wells, I therefore conclude they are about three miles diſtant from the river: thoſe we ſaw are ſcattered irregularly about the downs at no great diſtance from each other, ſome perhaps not more than thirty or forty yards. At this particular place we were informed there are 180 wells, four or five miles to the north-eaſt 340 more.

In making a well, the hill is cut down ſo as to form a ſquare table of fourteen or twenty feet for the crown of the well, and from this table a road is formed by ſcraping away an inclined plane for the drawers to deſcend, in raiſing the excavated earth from the well, and ſubſequently the oil. The ſhaft is ſunk of a ſquare form, and lined, as the miner proceeds, with ſquares of caſſia wood ſtaves: theſe ſtaves are about ſix feet long, ſix inches broad, and two thick; are rudely jointed, and pinned at right angles to each other, forming a ſquare frame, about four and a half feet in the clear for the uppermoſt ones, but more contracted below. When the miner has pierced ſix or more feet of the ſhaft, a ſeries of theſe ſquare frames are piled on each other, and regularly added to at top; the whole gradually ſinking as he deepens the ſhaft, and ſecuring him againſt the falling in of the ſides.

The ſoil or ſtrata to be pierced is nearly ſuch as I have deſcribed the cliffs to be on the margin of the river; that is, firſt, a light ſandy loam intermixed with fragments of quartz, ſilex, &c.; ſecond, a friable ſand-ſtone, eaſily wrought, with thin horizontal ſtrata of a concrete of martial ore, talc, and indurated argil (the talc has this ſingularity, it is denticulated, its lamina being perpendicular to the horizontal lamina of the argil on which it is ſeated) at from ten to fifteen feet from the ſurface, and from each other, as there are ſeveral of theſe veins in the great body of free-ſtone: thirdly, at ſeventy cubits, more or leſs, from the ſurface, and immediately below the free-ſtone, a pale blue argillaceous earth (ſchiſtus) impregnated with the petroleum, and ſmelling ſtrongly

ſtrongly of it. This, they ſay, is very difficult to work; and grows harder as they get deeper, ending in ſchiſt or ſlate, ſuch as found covering veins of coal in Europe, &c. Below this ſchiſt, at the depth of about 130 cubits, is coal. I procured ſome, intermixed with ſulphur and pyrites, which had been taken from a well, deepened a few days before my arrival, but deemed amongſt them a rarity, the oil in general flowing at a ſmaller depth. They were piercing a new well when I was there, had got to the depth of eighty cubits, and expected oil at ten or twenty cubits more.

The machinery uſed in drawing up the rubbiſh, and afterwards the oil from the well, is an axle croſſing the centre of the well, reſting on two rudeforked ſtaunchions, with a revolving barrel on its centre, like the nave of a wheel, in which is a ſcore for receiving the draw-rope; the bucket is of wicker work covered with dammer, and the labour of the drawers, in general three men, is facilitated by the deſcent of the inclined plane, as water is drawn from deep wells in the interior of Hindoſtan.

To receive the oil, one man is ſtationed at the brink of the well, who empties the bucket into a channel made on the ſurface of the earth leading to a ſunk jar, from whence it is laded into ſmaller ones, and immediately carried down to the river, either by cooleys or on hackeries.

When a well grows dry, they deepen it. They ſay none are abandoned for barrenneſs. Even the death of a miner, from mephitic air, does not deter others from perſiſting in deepening them when dry. Two days before my arrival, a man was ſuffocated in one of the wells, yet they afterwards renewed their attempts without further accident. I recommended their trying the air with a candle, &c. but ſeemingly with little effect.

The oil is drawn pure from the wells, in the liquid ſtate as uſed, without variation; but in the cold ſeaſon it congeals in the open air, and always loſes ſomething of its fluidity; the temperature of the wells preſerving it in a liquid ſtate fit to be drawn. A man who was lowered into a well of 110 cubits, in my preſence, and immediately drawn up, perſpired copiouſly at every pore: unfortunately I had no other means of trying the temperature. The oil is of a dingey green, and odorous; it is ufed for lamps, and boiled with a little dammer (a refin of the country), for paying the timbers of houfes and the bottoms of boats, &c. which it preferves from decay and vermin; its medicinal properties known to the natives are as a lotion in cutaneous eruptions, and as an embrocation in bruifes and rheumatic affections.

The miners pofitively affured me no water ever percolates through the earth into the wells, as has been fuppofed; the rains in this part of the country are feldom heavy, and during the feafon a roof of thatch is thrown over the wells, the water that falls foon runs off to the river, and what penetrates into the earth is effectually prevented from defcending to any great depth by the increafing hardnefs of the oleaginous argil and fchift: this will readily be admitted when it is known that the coal mines at Whitby are worked below the harbour, and the roof of the galleries not more than fifty feet from the bed of the fea: the deficiency of rain in this tract may be owing to the high range of mountains to the weftward, which range parallel to the river, and arreft the clouds in their paffage, as is the cafe on the eaftern fide of the peninfula of India.

Solicitous to obtain accurate information on a fubject fo interefting as this natural fource of wealth, I had all the principal proprietors affembled on board my boat, and collected from them the following particulars; the foregoing I learned at the wells from the miners and others.

I endeavoured to guard againft exaggeration, as well as to obviate the caution and referve which mercantile men in all countries think it neceffary to obferve when minutely queftioned on fubjects affecting their interefts, and I have reafon to hope my information is not very diftant from the truth.

The property of thefe wells is in the owners of the foil, natives of the country, and defcends to the heirs general as a kind of entailed hereditament, with which, it is faid, government never interferes, and which no diftrefs will induce them to alienate. One family, perhaps, will poffefs four or five wells; I heard of none who had more, the generality have lefs; they are funk by and wrought for the proprietors; the

the cost of sinking a new well is 2000 tecals flowered silver of the country, or 2500 sicca rupees; and the annual average net profit 1000 tecals, or 1250 sicca rupees.

The contract price with the miners for sinking a well is as follows:—For the first forty cubits they have forty tecals, for the next forty cubits three hundred tecals, and beyond these eighty cubits to the oil they have from thirty to fifty tecals per cubit, according to the depth (the Burmha cubit is nineteen inches English): taking the mean rate of forty tecals per cubit, and one hundred cubits as the general depth at which they come to oil, the remaining twenty cubits will cost 800 tecals, or the whole of the miner's wages for sinking the shaft 1140 tecals; a well of 100 cubits will require 950 cassia staves, which at five tecals per hundred will cost 47½ tecals. Portage and workmanship in fitting them may amount to 100 tecals more; the levelling the hill for the crown of the well, and making the draw road, &c. according to the common rate of labour in the country, will cost about 200 tecals; ropes, &c. and provisions for the workmen, which are supplied by the proprietor when making a new well; expenses of propitiatory sacrifices, and perhaps a signiorage fine to government for permission to sink a new well, consume the remaining 512½ tecals. In deepening an old well they make the best bargain in their power with the miners, who rate their demand per cubit according to its depth and danger from the heats or mephitic air.

The amount, produce, and wages of the labourers who draw the oil, as stated to me, I suspect was exaggerated or erroneous from misinterpretation on both sides.

The average produce of each well per diem, they said, was 500 viss, or 1825lbs. avoirdupois, and that the labourers earned upwards of eight tecals each per month: but I apprehend this was not meant as the average produce, or wages for every day or month throughout the year, as must appear from a further examination of the subject; where facts are dubious we must endeavour to obtain truth from internal evidence. Each well is worked by four men, and their wages is regulated by the average produce of six days labour, of which they have one-sixth, or its value, at the rate of one

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tecal and a quarter per hundred viſs, the price of the oil at the wells: the proprietor has an option of paying their ſixth in oil; but I underſtand he pays the value in money; and if ſo, I think this is as fair a mode of regulating the wages of labour as any where practiſed; for in proportion as the labourer works he benefits, and gains only as he benefits his employer. He can only do injury by over-working himſelf, which is not likely to happen to an Indian: no proviſions are allowed the oil drawers, but the proprietor ſupplies the ropes, &c.; and, laſtly, the king's duty is a tenth of the produce.

Now, ſuppoſing a well to yield 500 viſs per diem throughout the year, deducting one-ſixth for the labourers and one-tenth for the king, there will remain for the proprietor, rejecting fractions, 136,876 viſs, which at $1\frac{1}{4}$ tecal, the value at the wells, is equal to 1710 tecals per annum. From this ſum there is to be deducted only a trifle for draw-ropes, &c. for I could not learn that there were any further duties or expenſe to be charged on the produce; but the merchants ſay they gain only a neat 1000 tecals per annum for each well, and as we advance we ſhall have reaſon to think they have given the maximum rather than the minimum of their profits: hence, therefore, we may infer that the groſs amount produce per annum is not 182,500 viſs.

Further: the four labourers ſhare, or one-ſixth, deducting the king's tythe, will be 2250 viſs per month of thirty days, or in money at the above price twenty-eight tecals fifty avas, or ſeven tecals twelve avas each man per month: but the wages of a common labourer in this part of the country, as the ſame perſons informed me, are only five tecals per month when hired from day to day: they alſo admitted that the labour of the oil drawers was not harder than that of common labourers, and the employment no-ways obnoxious to health. To me the ſmell of the oil was fragrant and grateful; and, on being more indirectly queſtioned (for on this part of the ſubject, perhaps owing to the minuteneſs of my inquiries, I obſerved moſt reſerve), they allowed that their gain was not much greater than the common labourers of the country: nor is it reaſonable to expect it ſhould; for, as there is no

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myſtery in drawing of oil, no particular hardſhips endured, or riſk of health, no compulſion or prevention pretended, and as it is the intereſt of the proprietors to get their work done at the cheapeſt rate, of courſe the numbers that would flock to ſo regular and profitable an employment would ſoon lower the rate of hire nearly, at leaſt, to the common wages of the country: beſides, I obſerved no appearance of affluence amongſt the labourers, they were meanly lodged and clad, and fed coarſely, not on rice, which in the upper provinces is an article of luxury, but on dry grains and indigenous roots of the nature of caſſada, collected in the waſtes by their women and children. Further, it is not reaſonable to ſuppoſe that theſe labourers worked conſtantly; nature always requires a reſpite, and will be obeyed, however much the deſire of gain may ſtimulate, and this cauſe muſt more particularly operate in warm climates to produce what we often improperly call indolence. Even the rigid Cato emphatically ſays, that the man who has not time to be idle is a ſlave. A due conſideration of this phyſical and moral neceſſity ought perhaps to vindicate religious legiſlators from the reproaches too liberally beſtowed on them for ſanctioning relaxation: be that as it may, I think it is ſufficiently apparent that the article of wages is alſo exaggerated, and that 500 viſs muſt only be conſidered as the amount produce of working days, and not an average for every day in the year. The labour of the miners, as I have obſerved above, is altogether diſtinct from the oil-drawers, and their pay proportioned to the hardſhips and riſks they endure.

Aſſuming, therefore, as data, the acknowledged profit of 1000 tecals per annum for each well, which we can hardly ſuppoſe exaggerated, as it would expoſe the proprietors to an additional tax, and the common wages of precarious employment in the country, that is, one month with another, including holydays, the year round, four and a quarter tecals per month, as the pay of the oil-drawers, which includes the two extremes of the queſtion, it will make the average produce of each well per diem 300 viſs, or 109,500 viſs per annum, equal to 399,675 lbs. avoirdupois, or tons 178,955 lbs., or in liquid meaſure 793 hogſheads of ſixty-

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three gallons each; and, as there are 520 wells regiſtered by government, the groſs amount produce of the whole per annum will be 56,940,000 viſs, or 92,781 tons 1560 lbs., or 412,360 hogſheads, worth at the wells, at one and a quarter tecal per hundred viſs, 711,750 tecals, or 889,737 ſicca rupees.

From the wells, the oil is carried, in ſmall jars, by cooleys, or on carts, to the river; where it is delivered to the merchant exporter at two tecals per hundred viſs, the value being enhanced three-eighths by the expenſe and riſk of portage; therefore the groſs value or profit to the country of the whole, deducting five per cent. for waſtage, may be ſtated at 1,081,860 tecals, or 1,362,325 ſicca rupees per annum, yielding a direct revenue to the king of 136,232 ſicca rupees per annum, and perhaps thrice as much more before it reaches the conſumer; beſides the benefit the whole country muſt derive from the productive induſtry called into action by the conſtant employment of ſo large a capital on ſo gruff an article. There were between ſeventy and eighty boats, average burthen ſixty tons each, loading oil at the ſeveral wharfs, and others conſtantly coming and going, while I was there. A number of boats and men alſo find conſtant employment in providing the pots, &c. for the oil; and the extent of this ſingle branch of internal commerce (for almoſt the whole is conſumed in the country) will ſerve to give ſome inſight into the internal commerce and reſources of the country.

At the wells the price of the oil is ſeven annas ſeven pies per 112 lbs. avoirdupois; at the port of Ranghong it is ſold at the average rate of three ſicca rupees three annas and ſix pies per cwt. or per hogſhead of ſixty-three gallons, weighing 504 lbs. fourteen rupees ſeven annas nine pies, excluſive of the caſk, or per Bengal buzar maund two rupees five annas eight pies, whereas the muſtard-ſeed and other vegetable oils ſell at Ranghong at eleven rupees per buzar maund.

To conclude: this oil is a genuine petroleum, poſſeſſing all the properties of coal-tar, being, in fact, the ſelf-ſame thing; the only difference is, that nature elaborates in the bowels of the earth that for the Burmhas for which European nations are obliged to the ingenuity of Lord Dundonald.

XXIX. *Ac-*

## XXIX. *Account of Mr.* MUSHET's *new Method of making Steel of various Qualities.*

FOR this invention Mr. Mushet* has obtained his Majesty's royal letters patent; and, certainly, few discoveries of so much importance to this country have been made for a number of years past. The manufacture of cast steel, which has hitherto been tedious and expensive, is now reduced to a process of a few hours; and the quality of the article at the same time so much improved, as to be applicable to many purposes to which steel of the common manufacture cannot be applied. We shall not, however, dwell on the utility of the invention, but lay before our readers an account of it, extracted from Mr. Mushet's specification, which will speak more to an intelligent mind than would a volume of eulogium.

"The general principles of my process or processes are the fusion of malleable iron, or of iron ore, in such manner, and by such means, as immediately to convert them into cast steel; and, likewise, in certain cases, the after cementation of this steel to give it malleability, and the property of welding, in order to fit it for such purposes as require steel possessing these properties. These principles can be acted upon for the production of the various qualities of steel in a variety of ways; but the principle of my invention, and the mode of operation, may be fully understood by the examples which I shall adduce, and which will enable any person to perform the same, and to vary and alter the mode of operation according to his intention, and the particular quality of steel he may wish to manufacture.

"Thus, cast steel may be made by taking any convenient quantity of malleable iron, according to the size of the furnace and crucible or crucibles to be employed, and introducing it into the crucible or crucibles along with a proper proportion of charcoal, charcoal dust, pit-coal, pit-coal dust, black lead, or plumbago,

* The same gentleman to whom the public are indebted for the series of valuable papers on the manufacture of cast iron, given in the preceding volumes of the Philosophical Magazine.

plumbago, or of any fubftance containing the coally or carbonaceous principle; but, in general, charcoal, pit-coal, or pit-coal cokes, efpecially if prepared in the manner herein after defcribed, will be found to anfwer beft. For this procefs not only bar iron may be employed, but alfo what is commonly called fcraps, or wafte iron: but, when the latter is ufed, a little more carbonaceous matter muft be added to the mixture, to revive the ruft, or oxyd of iron, adhering to the fcraps. The mixture in the crucible or crucibles muft then be put into a furnace capable of giving a fufficiently intenfe degree of heat to run down or fufe the mixture, which muft then be poured out into bar, ingot, or other moulds, according as the manufacturer intends to produce bars or ingots, or various articles or utenfils that are, or may be, made of caft fteel; for the whole iron, by fufion with the charcoal or other fubftances or things containing carbonaceous matter, will be found to have paffed into the ftate of caft fteel. If caft into bars or ingots, and a proper quantity of charcoal, or other fubftances or things containing carbonaceous matter, has been employed, fuch bars or ingots will be found in a ftate ready to take the hammer, and to be drawn or rolled into other fhapes, according to the intention of the manufacturer. In fome cafes, efpecially where a heavy charge is to be run down, the crucibles muft be previoufly properly difpofed in the furnace, and the mixture introduced into them afterwards.

"By the procefs before defcribed, and which may be varied with circumftances by any prudent operator, caft fteel may be made in a few hours, which, by the procefs or proceffes hitherto difcovered, has ufually required many days, and fometimes weeks; for caft fteel, by the common method of manufacture, has been hitherto made from bar fteel, which had previoufly required, for its own converfion into that ftate, from the ftate of bar-iron, or of fcrap-iron, a tedious cementation with charcoal, in a furnace conftructed for the purpofe, and ufually known among manufacturers by the name of a converting furnace.

"It cannot here efcape obfervation, that this is not the only faving in point of time and expenfe, gained by my procefs cess or processes; for, when I meet with or procure iron-stones or iron-ores sufficiently rich, and free from foreign mixtures, I save even the time and expense necessary for the conversion of such iron-stone or iron-ore first into cast or pig-iron, and afterwards by a tedious and expensive process, accompanied with a great waste of metal, into bar-iron. For such ore or iron-stones, being previously roasted or torrified, when that process may be found necessary, which will often happen, may be substituted for the bar-iron, scrap, or waste iron, as before described, and the result will be cast-steel, if a proper quantity of charcoal, charcoal-dust, pit-coal, pit-coal-dust, plumbago or black lead, or of any substance containing carbonaceous matter, has been used.

"For the common and ordinary qualities of cast-steel, a much smaller quantity of carbonaceous matter is requisite in the mixture than perhaps could have been suspected before my invention. When charcoal from wood is employed, a seventieth to a ninetieth of the weight of the iron will generally be found sufficient. When the quantity of the carbonaceous matter or principle exceeds one seventieth, and is increased to from one sixtieth to one fortieth or more of the weight of the iron, the steel becomes so completely fusible that it may be run into moulds of any shape, and be capable afterwards of being filed and polished. Hence by casting may be constructed stoves, grates, kitchen utensils, many kinds of wheels and mill works, a great variety of small machinery, and many other articles, which could not be so made by the processes now in use, and which way of making such articles constitutes a part of my invention.

"By my process various kinds of steel, differing as much from each other in their qualities as the various kinds of pig or cast-iron differ from each other, can be formed by merely varying the proportion of carbonaceous matter. Cast-steel of the common and ordinary qualities is too volatile when in fusion to admit of being run into any shape except straight moulds of a considerable diameter; but steel of such density as to admit of being cast into any form may be produced by my process, by increasing the quantity of charcoal, or matter

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containing the carbonaceous principle, and then fufing the mixture as before directed. When I wifh to produce qualities of fteel fofter than is ufually manufactured by the common proceffes, I find it beft to ufe a fmall proportion of charcoal, fometimes fo little as a two hundredth part of the weight of the iron. Steel produced with any proportion of charcoal, not exceeding a hundredth, will generally be found to poffefs every property neceffary to its being caft into thofe fhapes which require great elafticity, ftrength, and folidity. It will alfo be found generally capable of fuftaining a white heat, and of being welded like malleable iron; and, indeed, as the proportion of charcoal or other carbonaceous matter is reduced, the qualities of the fteel will be found to approach nearer to thofe of common malleable iron.

"By further purfuing the principle of my new invention, I fufe down malleable bar or fcrap-iron in a crucible or crucibles, without any vifible addition of carbonaceous matter, and run it into bar, ingot, or other moulds. In this ftate the metal is nearly of the fame quality as when put in, only altered by the combination of a fmall portion of carbonaceous matter, which the iron by its chemical affinity attracts from the ignited fuel, or from the ignited carbonic gas of the furnace, and which enters by the mouth, or through the pores of the crucible or crucibles, probably diffolved in caloric at a very high temperature. But whether fo diffolved or not, the fact is, that a portion of the carbon paffes from the fire into union with the iron, and thereby converts it into an extremely foft fteel.

"Befides the different modes of operation above fpecified, I further reduce iron-ore, bar-iron, or fcrap-iron, by the addition of lime or chalk, or other carbonats, or of carburets, with clay, glafs, and other fluxes, in various proportions, and form all the various qualities of fteel formerly enumerated.

"If the various kinds and qualities of fteel obtained by the procefs or proceffes above mentioned be introduced into the common converting or other fteel furnaces, in contact with carbonaceous matter, or with earths, and heated for five days, or more or lefs, according to the thicknefs of the bars

bars or other forms, and the quantity introduced, the bars, ingots, or other ſhapes, being then taken from the furnace, will be found to poſſeſs all the ſolidity which they formerly were poſſeſſed of as caſt-ſteel, with that property of welding peculiar to bliſtered, faggot, or German ſteel of the uſual mode of manufacture.

"By this invention I obtain ſteel which for ſolidity may be uſed for the purpoſes of caſt-ſteel; uniting at the ſame time the property of welding, without deſtroying the ſolidity or quality of the metal:—a circumſtance of the higheſt importance to our manufacturers. Ingots, bars, plates, and every ſhape into which this ſteel is caſt, rolled, or hammered, will be poſſeſſed of uniformity of quality, without thoſe numerous reeds, flaws, biſters, and disjoined laminæ found in ſteel made by the proceſſes in uſe before my invention.

"When pit-coal cokes are to be uſed in any of the foregoing operations, either in mixture with the ore, or with the iron, or for fuel in the furnaces, in which the crucibles containing the mixture are expoſed to the action of the fire, it is of the utmoſt importance that the cokes be properly prepared. The proceſs which I have found to anſwer beſt for this purpoſe, though common cokes will alſo do, is founded upon the principle, that all acceſs of oxygen to the coals to be coked, ſhould be prevented: this end is gained by preparing the cokes in iron veſſels, in the ſame manner as wood is now charred for the purpoſe of being employed in the manufacture of gun-powder. The bitumen, or coal-tar as it is commonly called, which is volatilized from the coals to be coked, by the heat applied to the exterior of the iron veſſel or other chamber containing the ſaid coals, is thus ſaved, inſtead of being burnt or diſſipated in the atmoſphere, as is the caſe in the common proceſs of coking, in which the coals are expoſed to combuſtion in open heaps, and which alſo partially, though in a leſs degree, takes place in the proceſs commonly known by the name of Lord Dundonald's proceſs for preparing coal tar."

## XXX. *Experiments and Obſervations on the Vitality and Life of Germs.* *By* VICTOR MICHELOTTI, *M.D. of Turin**.

AS I propoſe to examine in this memoir the vital power, I have thought proper, in order that the ſubject may be rendered eaſier, to take vitality at that period of life when the number and complications of its functions are the leaſt; that is to ſay, in the embryo:—it is then reduced to ſimple nutrition and a ſpeedier increaſe.

We are as yet little acquainted with the powers by which the embryo is animated and expanded; the only object of the obſervations hitherto made on different kinds of eggs and ſeeds, was to prove or refute the ſyſtem of the pre-exiſtence of germs or at moſt to throw light on the formation and expanſion of ſome of their parts. It is on this power, however, with which living bodies are endowed, and the action of bodies which have ſome influence on it, that the phænomena of life depend.

But how comes it that certain agents which act with ſo much energy on adults ſeem to have no action on the fœtus, ſince the vital power and the *ſtimulus* employed are the ſame? Is there then at certain periods of life, a particular ſtimulus, deſtined to act on particular organs? or does ſenſibility vary in the different periods of life?

In ſupport of the firſt hypotheſis we might take light, for example, which appearing to be one of the vivifying principles of animals and vegetables, ſeems, however, to have no influence on the expanſion of germs, ſince the greater part of them paſs the firſt period of life in obſcurity.

But if we ſuppoſe a different ſenſibility in the various ſtates of life, we ſhall obſerve that the vivifying principle of the animal ought to be more energetic in proportion as it is nearer its ſource, ſince the whole ſpace paſſed over ought to be at the expenſe of the force employed to make it paſs.

One of the firſt modifications under which the vital power preſents itſelf is that of *irritability*; and it is exactly during the firſt expanſion of the fœtus that the greateſt, and as we

* From *Journal de Phyſique*, Ventoſe, an. 9.

may ſay, the moſt impatient irritability is obſerved. But why does a ſtimulus ſo powerful as caloric, in a certain doſe, extinguiſh the life of the adult, without altering, or, at leaſt, without altering much, the life of the ſame animal ſtill in embryo?

We have as little knowledge reſpecting the action of gaſes, odoriferous or narcotic effluvia, miaſmata, &c. In a word, there would be many agents to examine by applying them to animals externally; but I ſhall confine myſelf to an examination of the principal ones, and in the ſimpleſt and eaſieſt manner. 1ſt, Has light any action on the embryo ſtill contained in the egg? Is its action uſeful or prejudicial to it?

To decide this queſtion, I took on the 5th of December 1796, four glaſs jars of the ſame ſize, two of which I covered with a coating of black wax, and I put into each an equal quantity of the eggs of the *phalæna diſpar* Linn. I cloſed each of them with a pierced ſtopper, through which I inſerted a bent tube, coated in the ſame manner, to maintain a free communication between the internal and external air, preventing, as much as poſſible, the paſſage of light into the coated jars. I then placed in a northern expoſure a black jar and a tranſparent one in a ſituation where the ſun had no acceſs; the other two were expoſed to the ſouth, that is to ſay, to the moſt powerful action of that luminary.

In both places the greateſt cold during winter was + $18\frac{1}{2}°$ Fahrenheit, and the greateſt heat towards the north, that at the period of the birth of the caterpillars, was + 66°, while towards the ſouth in the ſun it was as high as + $109\frac{1}{2}°$.

On the 20th and 21ſt of April 1797, when the eggs of theſe phalænæ were not hatched in the fields, on viſiting my black jar towards the ſouth, I found the greater part of the eggs already hatched; the ſmall caterpillars had aſcended to the higheſt part of the neck of the jar, to which they had, no doubt, been attracted by ſome rays of light that, notwithſtanding my precautions, penetrated through the bent tube. On inſpecting at the ſame time the other jar towards

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the south, which was transparent, I found only one egg hatched. In another small transparent bottle, which contained some thousands of eggs, there were only five capable of being hatched, as all the rest had perished. I removed a bit of the black coating from the jar, that I might be able to observe the caterpillars; I left it exposed to the sun along with its companion, and I can assert, that after that period not one of the eggs was hatched, if I except the first and second day, when a few came forth.

The speedier hatching of the eggs in the coated jar might be ascribed to the greater degree of heat it experienced, if the air contained in the jar had not had free communication with the external air.

The jars exposed to the north, in such a manner as to receive only a reflected light, must inform us whether this light was equally sensible to the tender germs. On the 21st of April, indeed, I found several of them already hatched in the black jar, and three days after they began to become animated in a paper cornet, in which I kept a great number of them shut up, and it was not till the end of five days that they began to be hatched in the transparent jar exposed to the north.

I repeated these experiments in 1798, with this difference, that I varnished my glasses with oil colours, and that to the black transparent ones I added others covered with red and white paint.

The results were equally decisive, since at noon I saw all the eggs contained in the black jar hatched first, then a great part of those in the white, but none of those I left in the transparent one; on the contrary, they soon assumed a pearly gray colour, which I found by experience to be a certain sign that the eggs were no longer susceptible of being hatched.

The remaining eggs contained in the red jar and the white one towards the south became also gray, and incapable of being hatched. The experiment was attended with the same success towards the north, since the first hatched were those in the black jar, then those in the red and white ones almost

almoſt at the ſame time: thoſe in the tranſparent one were the laſt.

To anſwer an objection that might be made, that the different varniſhes produced a conſiderable difference in the heat in the glaſſes, (though this difficulty can have no relation to thoſe expoſed to the north,) I prepared, on the 5th of February 1798, two bent glaſs tubes, one of them varniſhed black, and put into each about a hundred of the ſame eggs. Theſe I inſerted in a pretty large bottle, not varniſhed, filled with water, which I took care frequently to change, leſt it ſhould become corrupted, and expoſed them to the ſouth.

On the 1ſt of March the eggs began to be hatched in the black tube, and eight days after in the other; before the end of the month 94 were hatched in the black tube, while in the tranſparent one there were only 41, the remainder having become gray, that is to ſay, having periſhed.

The conſiderable anticipation in the birth of the caterpillars in theſe tubes ought, in my opinion, to be aſcribed to their being immerſed in water, where they were not liable to changes of temperature ſo violent, ſince the cold was not greater than it had been the preceding year, and as the water contained in the bottle, during the greateſt heat, did not exceed 66° above zero; while in the jars expoſed to the ſun it roſe to + 88 and + 109, but towards the north it was only from + 55° to + 65, a temperature ſufficient to hatch the eggs of theſe inſects; and as the preſent year this degree of heat had been experienced more than uſual, it appears to be very probable that it is not a certain period of time that is neceſſary for hatching, but a certain degree of heat.

I repeated the ſame experiments on the *phalæna mori Linn.* (the ſilk-worm): the reſults were perfectly analogous to thoſe above mentioned. I ſhall not enter into all the details, but relate thoſe which I made on the eggs of a ſort of ſpider.

Theſe eggs being covered only with a very thin pellicle, appeared to me very proper for the experiment; and beſides this, the attention with which the mother envelops them,

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and conceals them in the crevices of trees, prepoſſeſſed me in their favour.

On the 26th of March 1800, I put on two pieces of white paper ſeveral of theſe eggs, which I covered with ſmall bells of very thin glaſs, taking care to leave a ſmall aperture at their ſummits to maintain a circulation of air. I varniſhed one of them black, and expoſed them to the ſouth.

At the end of ſome days the eggs which were under the tranſparent bell became coloured and dry, and all thoſe under the black bell were hatched on the 11th of April. I repeated on theſe eggs the experiments of the tubes immerſed in water, and the reſult was equally deciſive, ſince I ſaw hatched not only all the eggs contained in a bent glaſs tube covered with a very thin plate of lead, but ſtill they preceded others which, though placed alſo in a dark place, were not immerſed in water.

In regard to thoſe contained in the tranſparent tube, they all periſhed. At firſt they exhibited no ſenſible ſign of any change: afterwards they began to become a little coloured; they then daily aſſumed a redder colour, but they did not periſh altogether till the laſt days, during which thoſe in the covered tube were hatched.

From theſe different experiments we may therefore conclude, that light has a decided action on thoſe germs which are expoſed to it; that this action is prejudicial to them; and, in the laſt place, that it manifeſts its action by retarding their expanſion if the light be weak, or a reflected light, or by the total extinction of their life if it be very intenſe, as that which comes directly from the ſun.

To theſe facts if I add, that the expanſion of viviparous animals begins and is completed in darkneſs; that oviparous animals produce eggs with an opake ſhell, as thoſe of birds, &c. that if the eggs have a delicate ſhell the mother generally depoſits them in dark and concealed places, where ſhe covers them with hair, earth, &c. we ſhall be inclined to think that the action of light is generally prejudicial to the expanſion of the germs. But in what manner does it hurt them?—This is what I ſhall endeavour to explain.

It may be conceived that the action of light can hurt germs

germs three different ways; either by the deficcation it may produce by too much heating the bodies expofed to it; or by favouring new combinations between the almoft liquid parts of the germ, in fuch a manner as to deftroy their natural difpofition; or, in the laft place, becaufe, being itfelf a ftimulus, that is to fay, an agent capable of affecting vitality different ways, it may, by the violence of its intenfity, or the continuation of its action, extinguifh the vitality, as all ftimuli too violent or too long continued exhauft the fubject on which they act.

It may be readily feen that the firft hypothefis, that of the deficcation produced by the light of the fun, is void of all foundation, as is proved by the black jars expofed to the north, and the tubes which were kept immerfed in water.

In regard to the influence which light may have on germs, by facilitating or producing new combinations, it certainly deferves to be examined. It may, indeed, be eafily conceived that a new difpofition of the parts, contrary to that which is neceffary for the exercife of life, cannot take place without deftroying it; and we know by the different experiments of Hunter, how much power the vital principle has to caufe the germs of the eggs of fowls (which are eafily injured by froft when the vital principle is deftroyed) to refift cold with efficacy.

Harvey, and feveral other philofophers, have alfo obferved that the egg will keep as long as the membrane which contains the germ is found; and various obfervers have remarked, that the vital principle can even make the feeds of certain plants refift the injury of ages.

Infects which are fufceptible of a kind of refurrection are fo only as long as the vital principle exifts in them, by the means of which they refift the agency of deftructive powers; but, if thefe powers derange their organization, they irrecoverably lofe the faculty of refuming new life. That is to fay, in thefe animals, as in germs, the vital principle is always effentially united to a certain difpofition of organization, which is not changed till after the deftruction of the vital force.

It

It appears to me then that light destroys the vital principle of germs, and that after its destruction new combinations are formed.

The colour, indeed, which the eggs assumed during my experiments, never manifested itself without the destruction of life, and it never showed itself till the light had exercised on them a pretty strong action.

The total exhaustion of vitality effected by light, ought not to be different from that effected by other stimuli; that is to say, light weakens the germ, and consequently retards its expansion: in a word, by weakening and exhausting it it extinguishes its life; which is perfectly agreeable to what we have observed in eggs retarded in the process of hatching, or which perished, according to the intensity of the light they had received.

It might be conjectured that the light affects chiefly the nervous substance of the tender embryos, because we know the vehemence with which it affects, and in a very severe manner, our retina, when its action on it is too long continued. The existence of the pupillary membrane in the fœtus, and the pain experienced by young animals when first exposed to the light, are further proofs in favour of this hypothesis. In my eggs I could discover on the head of the insect those two hemispheres, with facets which afterwards formed the eyes of the insect; a proof of their advanced organization.

However plausible this reasoning might be, I was desirous of putting it to the test of experiment. As vegetables have no nervous substance destined for feeling, they appeared to me proper for this purpose. I therefore took French beans, (*phaseolus vulgaris Linn.*) chick peas, (*cicer arietinum*) lupines, (*lupinus albus*) and moistened them till they began to show signs of germination. I then removed the bark, and put them thus peeled into glass tubes with a little water. I immersed these tubes in a bottle of very thin transparent glass filled with water; some of the tubes I had wrapped up in a plate of lead, to shelter them from the light of the sun, and they were all kept at the same temperature. I first observed

ſerved in all the tubes a more rapid germination; I ſaw the ſeeds in the tranſparent tubes become equally yellow, but afterwards they began to putrefy without any further ſign of vegetation: on the other hand, the ſeeds contained in the tubes darkened by the plate of lead became yellow alſo; but, aſſuming afterwards a darker colour, they in a little time became green, threw out roots, expanded their cotyledons, and appeared in full vegetation. As the ſmallneſs of the tubes did not permit them to expand more, as ſoon as they filled the whole capacity of them they ceaſed to vegetate.

The different degrees of vegetation to which theſe ſeeds attained, ſhowed that light may have an influence on the ſeeds of vegetables, though deſtitute of nervous ſubſtance; but, that I might be fully convinced of this fact, I proceeded in the following manner:

I put ſome ſeeds of lupines and chick-peas, freed from their bark, and in a ſtate of germination, into two bottles, furniſhed at the bottom with a little tow moiſtened with water. I removed from the coated bottles a little of their varniſh on one ſide, in order that, being illuminated in that part, I might be able to obſerve through the aperture the vegetation of the ſeeds without being obliged to take them out.

The ſeeds at firſt continued to vegetate equally in the two bottles, and to throw out roots; but I ſoon obſerved that the extremity of the ſmall roots of the ſeeds contained in the tranſparent bottle began to aſſume a colour more and more dark, and they at length putrefied altogether. As ſome expanſion of the germ of the plant took place at this period at the expenſe of the cotyledons, and as the latter were moiſtened, it happened that the expanſion of the germ did not totally ceaſe, though it was very ſlow. The principal root even threw out ſome ſmall roots: but they ſoon rotted with the reſt; ſo that, after having languiſhed ſome time, the vegetation ceaſed altogether.

In the varniſhed bottle the caſe was different: all the ſeeds vegetated completely, ſent forth numerous roots in the tow, and only two ſeeds gave any ſign of putrefaction at the extremity of their principal root, while in the other parts they were ſound and vigorous, ſome of the plants even roſe to the ſummit of the bottle: in a word, I did not ſee any difference between theſe plants and thoſe which vegetate naturally in the earth, except that thoſe in the dark bottle had the ſtem and ſmall roots longer and whiter, and the cotyledons greener.

From theſe obſervations there is reaſon to conclude, that if philoſophers have been long acquainted with the influence of light on vegetation, they knew but imperfectly * that the firſt degree of vegetation, that is to ſay, the expanſion of the germs of plants, requires obſcurity like that of the germs of animals, ſince light is evidently prejudicial to them

If we recollect that the ſeeds of vegetables are all covered with a pretty hard opake bark, we ſhall be inclined to believe that this bark is not only deſtined to defend them from the prejudicial influence of the air, gaſes, &c. but alſo to ſhelter the tender and ſenſible germ from the action of the ſolar light, which would make them periſh.

I ſhall terminate this memoir with a remark which has occurred to me in regard to the lite of embryos. In my opinion, the vital power of embryos is expanded in a manner very ſimple and common to all germs, and the only object of it is the expanſion of thoſe organs, the exerciſe of which is to form afterwards real life. Though theſe organs all exiſt in the embryo, they have ſcarcely any influence on the actual life. The facts which induce me to entertain this opinion are, that the ſeeds of vegetables, deſtitute not only of eyes but even of a nervous ſyſtem, are nevertheleſs affected by light as well as the germs of animals.

Obſervations made on the reſpiration of the eggs of animals have ſhown me alſo that theſe eggs, during their expanſion, abſorb oxygen gas; if this gas is not ſupplied to them, their expanſion is ſuſpended; and this reſpiration or rather abſorption of air may be accelerated or ſuſpended by accelerating or checking the influence of the oxygen, which has an influence on the expanſion of the germ.

We are taught by the experiments of Mr. Cruickſhank

* Two able philoſophers, Senebier, and my countryman Vaſſalli, have made the ſame obſervation.

that

that barley, on germinating, abforbs oxygen gas; and that this abforption is in the ratio of the evolution of the germ. At this epoch of life, however, as the tracheæ of plants and animals do not feem to be proper for refpiration, I am of opinion that, as the germs which formed the object of my experiments were fenfible to the light, though deftitute of organs defigned for feeling, thefe young beings, thefe germs, abforb the air into thofe veffels which are one day to be their *organs of refpiration*. Germs, in expanding, live then and feel in a new manner which is peculiar to them.

*Additional Note* *.

It has been long obferved in gardens, in hot-houfes and hot-beds, that a fudden and ftrong light often deftroys in an inftant the young plants which have appeared. There are none, perhaps, which dread more the cold and the light than the germs of the larch, and fome other Alpine plants which, however, remain nine months of the year under the fnow, and the other three under a fcorching fun and the fereneft fky. They have need of being fheltered during their infancy, like the plants of the Cape. Would the cafe be different with the human race? It appears that general rules, like the maxims of philofophers, are every day contradicted by a kind and provident Nature, which knows to yield and to put herfelf within the reach of every being, and, without ftarts or agitation, to watch over their prefervation. Nothing lefs than direct experiments can check the influence of opinion, which, in confequence of the eloquence or reputation of great men, hurries away the indolence or indifference of the multitude. Thofe of Dr. Michelotti, which are really original, raife up a corner of that veil which covers the myfteries with which Nature is pleafed to conceal her productions. They are a leffon to mankind on the danger of deducing confequences too general from particular facts. In a word, they teach us, what it would appear good fenfe ought to have infpired long ago, that the firft, the moft ufeful, and the moft vivifying of all the elements of life may ex-

* By the Editor of the *Journal de Phyfique.*

tinguish, check, and suffocate it in a moment; such are caloric and light, given prematurely to the germs of plants and of animals.

*Mutata frangunt, adsueta conservant.* Linn.

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## XXXI. *Memoir on the Quantity of Vital Air in the Atmosphere, and the different Methods of measuring it.* By M. Anthony de Marti, *Member of the Royal Academy of the Arts and Sciences at Barcelona.*

THE celebrated Hales observed that common air, when exposed with other substances, was reduced to a smaller volume. Dr. Priestley advanced further in this matter, having discovered by his experiments that nitrous gas causes a diminution in air more considerable according as it is more proper for respiration; and on the other hand, that inflammable air, mephitic air, and other aëriform fluids incapable of maintaining animal life, do not in the like manner diminish nitrous gas. Other philosophers afterwards observed this diminution of air proportioned to its purity by means of liver of sulphur, a paste made of sulphur and filings of iron moistened with water, by the combustion of inflammable air, and by that of phosphorus. These substances, which absorb the respirable air to the exclusion of other aëriform bodies which may be mixed with it, have served as the means of ascertaining the purity of every kind of air whatever. Different kinds of eudiometric proofs have been employed: 1st, That of nitrous gas: 2d, That of sulphuret: 3d, That of a paste of sulphur and iron: 4th, That of inflammable gas: 5th, That of phosphorus. But have all these proofs been carried to such a degree of perfection as to render them equally convenient and correct? This examination will form the subject of this essay, which will naturally lead me to the analysis of atmospheric air.

This air is constantly found more or less impregnated with different heterogeneous bodies, and particularly water, the quantity of which M. De Saussure has shown us a method of meaſuring. But it contains alſo two aërial ſubſtances, *viz.* vital air, and mephitic air or azotic gas.

In a former memoir, publiſhed in 1787, I mentioned the opinion of Mr. Cavendiſh, that the vital air at London forms nearly a fifth part of the atmoſphere; ſo that 100 parts of atmoſpheric air contain 20 of vital air and 80 of mephitic air. Dr. Prieſtley thinks that the quantity of vital air is between 0·20 and 0·25. Scheele, who made his experiments at Stockholm during the year 1778, found that the quantity of vital air is between 0·24 and 0·30. Lavoiſier and other chemiſts at Paris are of opinion that it is nearly 0·28. From ſome experiments of Senebier there is reaſon to infer that the air of Geneva varies ſome hundredth parts, and that its portion of vital air exceeds 0·25. But other obſervations made in Europe, which are entitled to ſome confidence, ſeem to have proved that atmoſpheric air contains not more than 30 per cent. of vital air, nor leſs than 20. When I tranſmitted to this Society, in the month of June 1787, my Obſervations on the Vital Air of Plants, I announced that the common air which I had breathed at Altafulla, my native place, during the four preceding months, was of from 97 to 100 degrees; *viz.* that 100 parts of nitrous air and an equal quantity of common air, mixed in the manner of Ingenhouſz, were reduced 100 or 103; conſequently, from 97 to 100 parts had diſappeared. Since that time I have continued my experiments on the ſame ſubject, both by this and other proofs, to aſcertain whether this ſmall inequality might not ariſe from circumſtances attending the operation rather than from the nature of the air.

### *Proof by Nitrous Air.*

The proof by nitrous air is that which chemiſts have chiefly endeavoured to bring to perfection. Fontana, Prieſtley, Ingenhouſz, and ſeveral other chemiſts, have made many experiments to accompliſh that object; but this method preſents many difficulties to be overcome.

1ſt, The water in which the experiment is made is never pure. It contains a greater or leſs quantity of oxygen, azot, and carbonic acid, which it is not eaſy to determine.

 2d, Nitrous

2d, Nitrous air is not always of the same purity.

3d, The nitrous air is in part absorbed by the nitrous acid which is produced.

*Proof by Inflammable Air.*

It is then demonstrated that the eudiometric proof made with nitrous air is imperfect. The second proof, of which I must speak, practised by the means of inflammable gas, from its being an aërial body like nitrous gas, will be subject also to the same imperfection. For this reason I have not only given over using it, but, in considering the discovery of Mr. Cavendish, that a quantity of mephitic air may unite with vital air in the state of ignition, I must observe that, in the proof by inflammable air, which is burned with the air subjected to examination, the whole portion of vital air contained in the latter may not only disappear, but a certain quantity of mephitic air be absorbed, unless the two airs are entirely free from it, which cannot be known without great difficulty; and it will be necessary to calculate how much inflammable and azotic gas the residuum contains, to be able to ascertain, with sufficient exactness, the quantity of vital air which has disappeared, and which is the point to be determined.

*Proof by Phosphorus.*

It is therefore better that the substance employed for determining the purity of the air should not be gaseous, nor in a state of combustion. For this reason phosphorus, recommended by M. Achard as proper for eudiometric proofs, though a solid matter, may be liable to the same inconvenience; for not only the vital will lose its elastic form, but a part of its mephitic air will be absorbed.

*Proof by a Mixture of Iron and Sulphur.*

The proof which seems to be subject to no error, is that by a moistened mixture of sulphur and filings of iron. At first I employed this method as much as that by sulphuret, judging, with other philosophers, that they were equally proper. It is true, indeed, that both these substances absorb only that portion of vital air which is contained in the atmospheric air, leaving the mephitic air untouched; and thus, by by measuring the residuum of the quantity of air employed, the quantity which has disappeared, and which can be nothing but vital air, will be determined. During some days of the year 1787, in which the common air experienced no variation by the means of nitrous air, since 100 parts of each were uniformly reduced to 99 or 100, I was desirous of making a comparative trial of the same common air by means of iron and sulphur, and I observed that of 100 parts of air there remained from 79 to 81, and that, consequently, from 19 to 21 hundredths had disappeared. On similar days I exposed 100 parts of atmospheric air to liquid sulphuret, and found that the air lost between 21 and 23 parts. From this circumstance of always finding the results of the last proof higher, I began to suspect that sulphuret, and a mixture of iron and sulphur, ought not to be employed indifferently, but that the former ought to be preferred. When I recollected, indeed, the observations of Lavoisier on the formation of the vitriolic acid, and those of Dr. Priestley, that a paste of sulphur and filings of iron gave inflammable air in certain circumstances; I knew that during the absorption of vital air the latter unites itself with the sulphur, producing by the combination sulphuric acid, which, in exercising its action on the iron, produces a little inflammable air, which ascends to join itself to the azotic gas remaining in the upper part of the vessel after the operation; and though there really disappeared from 21 to 23 parts of vital air which enter into the composition of 100 parts of atmospheric air, it seems that only from 19 to 21 were really wanting; since, besides the 0·77 or 0·79 of mephitic air, 0·1 or 0·2 parts of inflammable gas united themselves also, from which there resulted from 0·79 to 0·81. It appeared not only from the experiments of common air, but from those also of another kind very superior, such as that extracted from the American agave, that a very small quantity more was diminished by sulphuret than by the mixture of iron and sulphur; so that air, extracted from that plant, with proper precautions, is so pure that sometimes it is found free from every other aërial substance, and is absorbed by the sulphuret without the residuum of a hundredth part.

Proof

*Proof by Sulphuret.*

The proof by fulphuret is that beft calculated to afcertain the quantity of vital air contained in any gafeous fluid, fince it will leave the mephitic air, and the other kinds of air which do not combine with it, without fear of any other gafeous fubftance being produced, or any loft, except the quantity of vital air, which alone has an affinity with the fulphuret, as I affured myfelf in 1787. A hundred parts of atmofpheric air expofed to fulphuret loft between 0·21 and 0·23; and as feveral other proofs on the fame air, made with nitrous gas, had taught me that it experienced no fenfible variation, I was then convinced that the air which we breathe in Catalonia is conftantly compofed of from 0·21 to 0·23 of vital air, and from 0·77 to 0·79 of azotic gas. To afcertain whether there might not be variations afterwards in the proportion of thefe two principles which conftitute in the atmofphere that elaftic fubftance on which our life chiefly depends, I continued my experiments by means of fulphuret.

In order to fhorten the operation, I provided fome glafs flafks of different fizes, each ending in a narrow neck, and furnifhed with a ground ftopper. I filled one of them with liquid fulphuret of lime, and, having immerfed the neck of it in water, I introduced into it, with the utmoft fpeed, through its orifice, a portion of atmofpheric air. The flafk being then ftopped was fhaken for a little time, and on examining it immediately I found its diminution complete. My refearches were foon after directed towards determining the refpective quantities of air neceffary to be introduced to that of the fulphuret, not only that I might learn the fhorteft poffible means of being able to effect my proofs, but alfo to afcertain whether they would be equally correct if made with a large or a fmall portion of vital air. Different experiments made with this view furnifhed me with the following obfervations:

A quantity of atmofpheric air, from a fourth part of a meafure to a whole one, which is the volume of an ounce of water, loft between 0·21 and 0·23, in flafks capable of containing from one and a half to fix meafures, filled with liquid fulphuret, ſulphuret, without being ſhaken, keeping the apertures unſtopped and immerſed in the ſame liquid, contained in a veſſel. Several other experiments gave me the ſame reſults.

A fourth part of a meaſure of common air, ſhaken with five meaſures or twenty times its volume of ſulphuret, loſt 0·26. I ſuppoſed that this ſubſtance, except the 0·21 or 0·22 of vital air, which compoſed the atmoſpheric air, had abſorbed alſo 0·5 of its mephitic air. I thence concluded, that if I ſhould ſhake another equal quantity of common air in the ſame ſulphuret, which by the preceding manœuvre I conſidered as already united with all the mephitic air it could take up, it would not decreaſe more than from 0·21 to 0·23; and, indeed, this was the reſult. I immediately introduced an equal quantity of mephitic air, which ſuſtained no loſs by the agitation of the ſame ſulphuret, which muſt have been already impregnated with it. But on ſhaking this mephitic air in a flaſk containing alſo five meaſures of ſulphuret, differing from the other only in this, that it had not been before ſhaken with any air, it loſt 0·05; which is the difference of 21 and 26. It is therefore evident that ſulphuret is capable of containing a certain portion of mephitic air; and the more it is deprived of it, the greater will be the abſorption of atmoſpheric air. This fact was proved by the following experiment:—I filled a flaſk, capable of containing five meaſures, with ſulphuret newly made, and ſtill in a ſtate of ebullition, and which, conſequently, was free from gaſeous matter: and without giving it time to abſorb any, I corked it up, and when it had cooled I introduced the fourth part of a meaſure of atmoſpheric air, which being regularly ſhaken from three to five minutes, loſt 0·50; that is to ſay, one-half of the whole. In this caſe then, beſides the 0·21, it abſorbed 0·29 of mephitic air; and I really found this to be the caſe, by trying one-fourth of a meaſure of mephitic air, which was ſhaken in the ſame flaſk, with freſh ſulphuret, in every thing ſimilar to the former. The hundredths wanting between 29 and 50, which are 21, indicate the quantity of vital air only which had diſappeared in the proof of the atmoſpheric air. After this it may be eaſily conceived that this air will

decreaſe

decreafe in proportion as the refpective quantities of the fulphuret fhall be greater.

I fhall now proceed to explain my method of operation, which, after feveral trials, appeared to me the fimpleft and the moft correct. I have employed it for a long time without having obferved the difference of a hundredth in the refults.

My whole apparatus is a glafs tube five lines in diameter, and ten inches in length: it is clofed at one of its extremities, and divided on the fide into 100 equal parts, each of a line, and which all together are capable of containing about an ounce of water. As the common air is found every where, to take a quantity correfponding to the 100 divifions nothing is neceffary but to fill the tube with water, keeping it in a perpendicular pofition, with the aperture downwards. The finger applied to the aperture muft be removed at intervals, and the tube inclined a little, by which means the external air, if the tube be at the furface of the water, will enter it; and, when it occupies the 100 lines, it muft be ftopped, keeping the orifice clofed by the finger. The tube muft be immerfed in the water tub, that it may affume the fame temperature. When it is taken out, it muft be examined whether the air furpaffes or not the fpace of 100 lines, to take away or add the quantity neceffary to make it ftand exactly on a level with the place where the divifions begin. I then introduce this air in the ufual manner into a flafk containing from twice to four times its volume of liquid fulphuret of lime, previoufly impregnated with azotic gas. I then ftop it, and fhake it for five minutes; after which I transfer the air back into the graduated tube, and find that the aëriform fluid, which before occupied 100 divifions exactly, occupies, after the operation, only 79; and, confequently, 21 parts have difappeared. If the graduated tube ends in a neck with a ground ftopper, inftead of water it may be firft filled with fulphuret, and by proceeding as above the operation will be fpeedier, without having occafion to employ water, or to introduce air into the flafks, and to transfer it. To try another refpirable air, however, not atmofpheric, fimilar transfers are indifpenfable, as is evident, and they may be executed with the greateft convenience, by means of Fontana's fmall meafure.

In

In examining vital air, ſuch as that which iſſues from plants expoſed to the ſun, it ſometimes happens that the eudiometric proof muſt be performed with a ſmall quantity: if the air collected occupies only the ſpace of 25 lines, inſtead of a hundred, it is evident that a hundredth inſtead of a line will correſpond to a fourth part of one; but in portions of air ſtill leſs, as the diviſions would be inſenſible, a tube of a leſs diameter muſt be employed. With this precaution, and that of not forgetting to ſhake the ſulphuret before with mephitic air, in order to ſaturate it fully, and of employing flaſks proportionally leſs, thoſe who have acquired the practice and addreſs neceſſary for ſuch experiments will never find the difference of a hundredth part.

I repeated them ſo many times with atmoſpheric air, and on ſo great a number of days, that the uniformity in my reſults demonſtrates not only the exactneſs of this method, but it ſeems to reſult from my obſervations made on the ſouthern coaſt of this province:

1ſt, That the wind never cauſed the variation of a hundredth part in the reſpective quantities of vital air and azotic gas which compoſe the elaſtic fluid of our atmoſphere, ſince I have always found that a hundred parts contained 79 of the latter and 21 of the former, without ever reaching at 22.

2d, That neither the moiſture nor dryneſs of the atmoſphere, nor the ſtate of the latter in being more or leſs charged with exhalations, nor ſerene or rainy weather, occaſioned any difference. It cannot be denied that, in an equal ſpace of the atmoſphere, as the aëriform fluid contains a greater portion of water diſſolved, and more impregnated with other heterogeneous bodies, there cannot be found the ſame quantity of air free from foreign matters; but the number 21 of the vital part, found ſo many times in the two caſes, ſhows that the elements which conſtitute its elaſtic portion, ſo valuable and ſo abundant, are reſpectively invariable.

3d, That the proportion of the quantities of the two ſame principles was equally conſtant during the days that Reaumur's thermometer ſtood at the freezing point, as well as during thoſe when it indicated 24 degrees of heat.

4th, That I did not obſerve any variation in the air thus taken

taken while the mercury of the barometer was very low, and when it exceeded 28 inches.

If the greatest variations in the heat and pressure of the atmosphere observed in this country did not occasion any variation in regard to the respective quantities of the two aëriform fluids which compose it, neither did the dilatation or compression of the same common air, which is in the compound ratio of the variations of the heat and pressure, occasion any difference. The mephitic air being the only one of all the aërial substances which I found incapable of being combined with water, this unalterability suggested to me the idea of composing a permanent instrument for ascertaining the greatest or least dilatation which the atmospheric air experiences either from one of the two causes above indicated, or from both of them united. I took a glass tube of a small diameter, and, having filled it with water, I then introduced into it a quantity of mephitic air, the space occupied by which was divided into a hundred equal parts. This small tube I put into another larger one containing also water to a determinate and constant elevation, and which was left open to receive the impressions made by the variation of the atmosphere, which, pressing more or less on the column of mephitic air, made it extend in proportion, and with so much exactness and permanency, that at the end of some months it retained the same dimensions, which the barometer and thermometer showed to be those corresponding to the degrees of pressure and heat. This simple instrument enabled me to correct, with the greatest precision, the error which sometimes arises from the difference in the dilatation of the air which I examined, and which might readily occur during the long time necessary to complete the proof by sulphuret without agitation, observing the hundredth parts it marked at the beginning and the end of the operation. By similar corrections this method, though of long duration, corresponds exactly with that of shaking the sulphuret, during which, as the change of dilatation does not take place, the number constantly indicated is 21 complete. In a word, during winter, in summer, in spring, and in autumn, in every month and at all hours, I found the air of my country, taken in the open

open fields, to be always composed of from 21 to 22 parts of vital air, and of from 78 to 79 of azotic gas; and if at any time, which however very rarely happened, the result varied a few hundredth parts, the succeeding experiment, which I could repeat with the greatest facility, and in a few minutes, soon detected the error. I was convinced that this small difference did not arise from the nature of the air, but from some negligence in the operation. I have often collected air in places where a great many persons were assembled, or near ponds of stagnant water, and I always found this air as pure as the common air.

It cannot be denied that stagnant water, the surface of which occupies a considerable space, may produce insalubrious effects; but it appears no less certain that insalubrity cannot arise from the disproportion between the vital and mephitic air in the atmosphere; for the difference was not sensible by a hundredth part. It is well known that three different kinds of air are disengaged from stagnant water, *viz.* mephitic air, inflammable air, and carbonic acid gas; all incapable of maintaining animal life: but we must suppose that these fluids are disengaged in bubbles and in a very small quantity in regard to a great extent of atmospheric air; that the last, being more ponderous than common air, must be immediately precipitated, or combine with the water suspended in it; that the second, being lighter, must rise to the higher regions; and, in the last place, that the first being of equal density must rapidly penetrate and lose itself in the immense space.

It would therefore excite no surprise if all these aërial substances should alter the quantity of the elastic portion of the atmosphere, so that the difference should become perceptible by some hundredths in the proportion between the quantity of vital air and that of the other fluids it is capable of containing; but if this variation in air, collected in places where emanations of non-respirable kinds of air are known to exist, does not rise to a hundredth part, how is it possible that, at a great distance from the sphere of the activity of these partial causes, there should be greater variations, which some philosophers pretend to have observed not only in different months,

 but

but at different hours of the fame day? It muft certainly be afcribed to the imperfection of our inftruments, or to fome negligence in the mode of operation, if confiderable inequalities are fometimes obferved in the purity of the air around us; and repeated experiments give me reafon to think that, wherever there is a free communication with the vaft receptacle of the atmofphere, the air which we breathe will always be found to confift of from 0·21 to 0·22 of vital air, and from 0·78 to 0·79 of azotic gas, provided it be examined with the precautions which I have here pointed out.

If eudiometric proofs are not fufficient for explaining the dangerous effects experienced in the neighbourhood of ftagnant waters, the caufe might perhaps be found by analyfing the water that floats in the atmofphere. The obfervations of Berthollet prove that volatile alkali is compofed of azot and hydrogen deprived of caloric, or of that principle which before kept them feparate in an elaftic form, and we know that thefe two fluids are difengaged from ftagnant waters: may we not then prefume that its alkaline portion, always the fame in its modifications, is in part decompofed; and that a large quantity, not decompofed, either alone or combined with fome other unknown fubftance, is eagerly abforbed by the water, as its putrid fmell in evaporating feems to indicate; and, confequently, remaining diffolved in the portion of water fufpended in the neighbouring air, it produces certain alterations in regard to animal life?

It is not impoffible to collect fuch a quantity of this water as to be able to examine it: the products given by the means of analyfis, compared with thofe of other water fufpended in air contiguous to running water, might ferve, perhaps, to make known the caufe of the infalubrity of ftagnant water. Eudiometric experiments have not been able to throw light on this difficulty, and have taught us only that we ought not to afcribe the infalubrity of certain places to the exiftence in the atmofphere of a quantity of aëriform fluids too great for that of vital air.

But though this proportion does not vary a hundredth part in the courfe of feveral months, and even years, may it vary a very fmall part, fuch as a thoufandth part, which after a

very

very long time may become sufficiently sensible to make the proportion of the vital air of the atmosphere experience a progressive or periodical increase or diminution? The experiments which I have hitherto made are not sufficient to enable me to ascertain whether there be such a difference of some thousandth parts, and this could not be known even by employing more considerable portions of common air and very long tubes. Observation, indeed, shows that sulphuret may contain, interposed between its particles, a certain portion of mephitic air, and we do not know whether it may not vary some small part; besides, the particles of the water, which are more or less adhesive to the inner surface of the tube, whatever care may be taken, difference of temperature and other causes united, though they can be so far avoided as not to have in the resust of the operation the error of a hundredth part, are capable of occasioning, sometimes, others less considerable, such as of a thousandth part, unless a degree of attention of which few persons are capable be employed.

Though we may consider, as exact, in general, the analysis of natural productions carried to that degree of perfection yielded by eudiometric proofs; yet it is not impossible, for several reasons, that greater exactness might be attained to resolve the proposed question. Those would certainly be in an error who should calculate the loss of vital air produced in the atmosphere from the causes of its destruction already known: they would certainly find it impossible that many years could elapse without its becoming perceptible; the quantity which animals consume being very great, as well as that consumed by combustible bodies, with which it combines during the act of combustion. Consequently, posterity would be forced to respire an air more charged with mephitic gas than that which we breathe at present. But we are not entirely ignorant of the means which the Divine Providence employs for restoring that active fluid to the common receptacle, viz. plants acted upon by the rays of the sun. It is not, however, possible to calculate the quantity of the vital air which the atmosphere recovers from that quarter. We have reason to expect that the observers of nature will discover other causes of the addition of

vital

vital air, or, perhaps, of the destruction of mephitic air in the atmosphere, to compensate the losses it sustains, and to maintain constantly the quantity requisite for the preservation of the inhabitants of the earth, without producing a continued increase or diminution in the aërial substances of which the atmosphere is composed. What disorders might ensue if a few hundredth parts of vital air only were wanting? Fire would lose its strength, candles would not diffuse such complete light, and animals would with difficulty receive the vivifying air. No less inconveniences would arise if the atmosphere, on the other hand, were more charged with vital than mephitic air. Animals indeed, by these means, would acquire a freer respiration; but let us only consider the activity which fire would acquire by air of superior purity. We know that, on some occasions, the least spark excites the strongest flame in a combustible body, and which increases so much as to consume it in a few moments: candles then would be no sooner lighted than they would be destroyed, without answering any other purpose than that of dazzling us for a few moments: iron would be calcined, instead of acquiring from the fire that softness necessary for transforming it into various instruments, and which it cannot receive in a more moderate heat. Nothing would be capable to check the progress of this destructive element, which is nourished by vital air, if this aëriform substance were not abundantly mixed with mephitic air, which serves to restrain it.

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## XXXII. *A Treatise on the Cultivation of the Vine, and the Method of making Wines.* By C. Chaptal.

[Continued from Page 134.]

### III. *Of the Means requisite to dispose the Wine for Fermentation.*

As ripe grapes rot on the twigs, the faculty which the sweet and saccharine juice of the fruit possesses of being converted into a spiritous liquor may be considered as the pure effect of art, and it is by the fermentation of this juice expressed preffed that this change is produced. The method of difpofing grapes to fermentation varies in different countries; but as the differences occafioned in fo effential an operation reft on certain principles, I have thought it proper to make them known.

We are informed by Pliny (*De brio vino apud Græcos clariffimo*, that the grapes were collected a little before their maturity; that they were dried by being expofed to the ardent fun for three days, turning them three times every day, and that on the fourth they were expreffed.

In Spain, particularly in the environs of St. Lucar, the grapes are left expofed for two days to the full ardour of the fun.

In Lorraine, part of Italy, Calabria, and the ifland of Cyprus, the grapes are dried before they are expreffed. It is in particular when white fweet wines are to be made that the grapes are dried, to thicken the juice, and thereby to moderate the fermentation.

It appears that the antients were acquainted not only with the art of drying the grapes in the fun, but even that they were not ignorant of the procefs employed to boil and concentrate the muft; on which account they diftinguifhed wines into three kinds, *paffum*, *defrutum*, and *fapa*. The firft was made from grapes dried in the fun; the fecond was obtained by reducing the muft one-half by the means of heat; and the third, from muft fo concentrated that there remained no more of it than a third or a fourth. For very interefting details refpecting thefe operations the reader may confult Pliny and Diofcorides. Thefe methods are ftill ufed at prefent, and we fhall fhow, when we come to fpeak of fermentation, that it may be directed and managed in an advantageous manner by infpiffating a portion of muft, and afterwards mixing it with the remainder of the mafs; we fhall fhow alfo that this is an infallible method for giving to all wines a degree of ftrength to which the greater part of them cannot otherwife attain.

Agriculturifts were long divided in regard to the queftion, whether it is moft advantageous to free the grapes from the ftalks or not? Each of thefe methods has its partifans, and

 writers

writers of merit may be quoted who have ſupported both. In my opinion, in this as well as in other caſes, both parties have been too excluſive, and by bringing back the queſtion to its real point of view it will be eaſy for us to terminate the difference.

It is certain that the ſtalks are harſh and auſtere, and it cannot be denied, that wines produced from grapes not freed from the ſtalks do participate in that quality: but theſe are weak and almoſt inſipid wines, ſuch as the greater part of thoſe made in moiſt countries, where the ſlightly harſh taſte of the ſtalks heightens the natural inſipidity of that beverage. Thus, in the Orléanois, agriculturiſts, after freeing the grapes from the ſtalks, have been obliged to abandon this method, becauſe they obſerved that the grapes freed from the ſtalks furniſhed wines more inclined to become oily. It reſults alſo, from the experiments of Gentel, that fermentation proceeds with more force and regularity in muſt mixed with the ſtalks than in that which has been freed from them; ſo that in this point of view the ſtalks may be conſidered as an advantageous ferment in all caſes where it is to be apprehended that the fermentation may be too ſlow or retarded.

In the environs of Bourdeaux the red grapes are carefully freed from the ſtalks when it is propoſed to obtain good wine. But this operation is ſtill modified according to the degree of the maturity of the grapes. It is much employed when the grapes have little ripeneſs, or when froſt has taken place before their being collected; but when the grapes are very ripe, it is performed with leſs care. Labadie obſerves, in the information with which he has ſupplied me, that the ſtalks muſt be left to facilitate the fermentation.

White grapes are never freed from the ſtalks; and experience proves, that grapes ſeparated from the ſtalks give wines leſs ſpiritous, and more ſuſceptible of becoming oily.

The ſtalks, no doubt, add neither to the ſaccharine principle nor to the aroma; and in this double point of view, they cannot contribute by their principles either to the ſpiritous quality of the wine or to its flavour, but their ſlight auſterity may correct, with advantage, the weakneſs of ſome wines;

wines; and besides, by facilitating the fermentation, they concur to effect a more complete decomposition of the must, and to produce all the alcohol it is susceptible of yielding.

Without wandering from the subject in question, we may consider wines also under two points of view, according to the uses to which they are applied. They are all employed either as a beverage or for distillation. In the former, qualities are required which would be useless in the second. Taste, which forms almost the whole merit of the one, adds nothing to the qualities of the other. Thus, when wine is destined to be distilled, it is necessary to pay attention only to the means of developing a great deal of alcohol: it is of little importance whether the liquor be tart or not; in this case, to free the grapes from the stalks would be lost labour. But if wine is prepared for a beverage, it is then necessary to give it an agreeable taste and a delicate flavour, and for this purpose, care must be taken to avoid every thing that may alter these valuable qualities. On this account, therefore, it is necessary to withdraw the stalks from the fermentation, to pick the grapes, and to clean them with care.

It is, probably, in consequence of a knowledge of these effects, which experience every day places before the eyes of the agriculturist, rather than from caprice or habit, that in certain countries the grapes are freed from the stalks, and that this process is omitted in others. To attempt to reduce the whole to one general method would be showing ignorance of the effects produced by the stalks in fermentation, and of the difference which exists in the various qualities of the grapes. In the south, where the wine is naturally generous, the stalks would only add a disagreeable harshness to a liquor already too strong by its nature. All the grapes, therefore, destined to form wines for the table, are freed from the stalks, while those destined for distillation are fermented with them. But what may appear astonishing is, that in different parts of the same canton in France, we see some agriculturists free their grapes from the stalks, and extol their method, while others in the neighbourhood, equally skilful, reject this practice, and endeavour to support their method by the reſult of their experience. The one makes wines more delicate, the other wines of a ſtronger quality; both find partiſans of the liquor which they prepare: but this is a matter of taſte, which does not contradict the principles we have here laid down.

In general, a fork with three prongs, which the workman turns and agitates in a circular manner in the vat where the grapes are contained, is employed for freeing them from the ſtalks. By this rapid motion the ſtalks are detached from the grapes, and, being drawn up to the ſurface, are removed with the hand.

They may be freed from the ſtalks alſo by means of a common ſieve formed of oſier twigs, diſtant from each other about half an inch, and having above it a cloſe oſier pad or preſſer, about four inches thick.

But whether the grapes be freed from the ſtalks or not, it is indiſpenſably neceſſary to tread them, in order to facilitate the fermentation, and this proceſs is performed as the grapes are collected and brought home from the vineyards. The operation is nearly the ſame in all the wine countries, and is performed, for the moſt part, in a ſquare box, open at the top, and about a yard and a half in breadth. The ſides conſiſt of wooden bars, with intervals of ſuch a ſize that the grapes may not paſs through them. This box is placed on the vat, and kept in its poſition by two beams reſting on the edge of the veſſel. The grapes are poured into this box as they arrive from the vineyards, and are immediately trod, in a ſtrong and equal manner, by a man, having on his feet large wooden clogs, or ſtrong ſhoes. While employed in this labour, he reſts with his two hands on the edge of the box, ſtamping with rapidity on the ſtratum of the grapes, while the expreſſed juice runs into the vat through the interſtices left between the bars. Nothing remains in the box but the pellicle and ſtalks of the grapes; and when the workman finds that all the juice is expreſſed, he raiſes a plank, which forms a part of one of the ſides of the box, and puſhes the ſkins and ſtalks with his foot into the vat. This door ſlides in two grooves, formed on two perpendicular bars. As ſoon as the box has been cleaned,

a new

a new quantity of grapes are introduced to be trod in the fame manner; and this operation is continued till the vat is full, or until the vintage is terminated.

In fome countries the grapes are trod in tubs. This method is perhaps better in regard to the effect than the former, but it is flower, and cannot be employed in countries where the vineyards are of great extent.

There are fome countries alfo where the grapes are poured into the vat as they come from the vineyards; and when fermentation begins to take place, the muft, which floats on the furface, is carefully removed in order to be conveyed to the cafks, where the fermentation is completed. The refiduum is then fqueezed under a prefs, to form wine of a higher colour and lefs flavour.

In general, whatever be the method employed in treading the grapes, what concerns this important operation may be reduced to the two following principles:

Grapes cannot experience fpirituous fermentation unlefs the fugar be extracted by proper preffure, in order that it may be fubjected to the action of thofe caufes which determine the movement of fermentation.

It follows from this fundamental truth, that not only the means proper for treading the grapes ought to be employed, but that the operation will not be complete unlefs all the grapes are equally preffed; without this the fermentation can never proceed in an uniform manner: the period of the decompofition of the expreffed juice would terminate even before the grapes which efcaped being trod upon had begun theirs, and there would thus be produced a whole, the elements of which would no longer bear relation to each other. However, on examining the product depofited in the vat after the treading is finifhed, it will readily appear that the compreffion has been always unequal and imperfect; and by reflecting a moment on the rude proceffes employed for treading the grapes, there will be no reafon for being aftonifhed at the imperfection of the refults.

It appears, then, that to give to this very important part of the labour of the vintage the neceffary degree of perfection, it would be neceffary to fubmit to the action of the prefs all the grapes as they are brought from the vineyard. The juice would be received in a vat, where it might be left to spontaneous fermentation. By this method alone the movement of decompoſition would be exerciſed on the whole maſs in an equal manner; the fermentation would be uniform and ſimultaneous in regard to all the parts; and the ſigns which announce, accompany, or follow it, would not be diſturbed or obſcured by particular movements. The muſt, freed from the ſtalks and huſks, would no doubt produce wine leſs coloured, more delicate, and more difficult to be preſerved; but if the inconveniences of this method exceeded the advantages, it would be eaſy to prevent them by mixing the expreſſed refuſe with the muſt.

In conſequence of theſe principles, care ought to be taken to fill the vat in twenty-four hours. In Burgundy the vintage is terminated in four or five days. Too long time would be attended with the diſagreeable inconvenience of a ſucceſſive ſeries of fermentations, which, on that account alone, would be all imperfect; a portion of the maſs would be already fermented, while the fermentation would be ſcarcely begun in another. The wine thence reſulting would then be a real mixture of ſeveral wines more or leſs fermented. The intelligent agriculturiſt, therefore, anxious for the quality of his products, ought to determine the number of the vintagers according to the known capacity of his vat; and when unexpected rain makes him ſuſpend the labour of collecting the grapes, he ought to leave to ferment ſeparately the juice of thoſe already collected and placed in the vat, rather than run the hazard of expoſing himſelf ſome days after to the danger of interrupting its movements and altering its nature by the addition of freſh and aqueous muſt.

[To be continued.]

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## XXXIII. *Account of New Publications.*

*Philoſophical Tranſactions of the Royal Society of London for* 1800. *Part III.* 4*to.* Elmſly.

THIS part contains: Experiments on the Solar and on the Terreſtrial Rays that occaſion Heat; with a comparative View

View of the Laws to which Light and Heat, or rather the rays which occasion them, are subject, in order to determine whether they are the same or different. Part II. By William Herschel, LL.D. F.R.S. And, An Account of the Trigonometrical Survey carried on in the years 1797, 1798, and 1799, by order of the Marquis Cornwallis, master-general of the ordnance. By Captain William Mudge, of the Royal Artillery, F.R.S. Communicated by his Grace the Duke of Richmond, F.R.S.

*The Physical Principles of Chemistry.* By M. J. BRISSON, *Member of the French National Institute, and Professor of Chemistry in the Central School of Paris. Translated from the French. Illustrated with Engravings.* 8vo. Cuthell, and Vernor and Hood.

THE present work contains much useful matter, well digested, well arranged, and compressed into as little bulk as its nature could admit of, without omitting any thing necessary in an elementary treatise.

The tables of the combinations of all the acids with the salifiable bases, in the order of their affinities, so far as yet known, are so ample that the work cannot fail to prove extremely useful even to those who are well acquainted with chemistry; and the various processes, which are detailed with precision, yet without prolixity, are illustrated with engravings of the necessary apparatus, executed in a masterly manner by Lowry.

The work possesses considerable merit, and the translation is well executed. The following extract will serve as a specimen of both:

" *Nitrous Gas.*

" Nitrous gas was discovered by Hales; but Priestley made known the greater part of its properties. It does not exist in a natural state, and must be obtained by the assistance of art. It is one of the constituent parts of the nitrous acid; and it would be nitrous acid itself, were it not deprived of a large portion of its oxygen, which makes it cease to be an acid. It is composed with the same base as that of the nitrous acid, which is azot holding in a state of gas two

parts

parts of oxygen; that base being combined with caloric. In this state it is not soluble in water; but if you furnish it with a third part of oxygen, by combining with that excess, it becomes acid, and very soluble in water. If in one part therefore of azot there are only two parts of oxygen, it is merely a nitrous oxyd; which is the base of nitrous gas; if there are three parts of oxygen, it forms fuming nitrous acid; if there be four parts, the result is white nitric acid; These two last compounds are acid, and perfectly soluble in water; the first is neither acid nor soluble.

"It may easily be shown, both by analysis and synthesis, that the base of the nitrous acid is azot combined with oxygen, but not to saturation, which would make it nitric acid. 1st, By analysis. Nitrous acid may be decomposed by making it act on some metal (copper, for example) which takes from it a part of its oxygen, and reduces it to the state of nitrous gas; if you then expose this nitrous gas over an alkaline sulphuret which will deprive it of the rest of its oxygen, nothing will remain but azotic gas, therefore, &c. 2d, By synthesis. Mr. Cavendish formed nitrous acid by exposing seven parts of pure air and three of azotic gas to the action of the electric fluid; the azot combined with the oxygen of the pure air, and the result was nitrous acid: the base of nitrous gas therefore is azot combined with oxygen.

"Nitrous gas therefore may be obtained from the nitrous or nitric acid, made to act on combustible matters. These matters combine with a greater or less portion of the oxygen of the acid, while the azot, which retains a part of the oxygen by combining with caloric, forms nitrous gas, which passes into the bell placed to receive it. The substances proper for this purpose are iron, copper, brass, tin, silver, mercury, bismuth, and nickel. It may be extracted also by means of gold and antimony from the nitric acid, which makes a component part in the nitro-muriatric acid employed to dissolve these metals. It may be extracted also from the nitrous acid, by making it to act on alcohol, ether, oils, resins, gums, charcoal, sugar, &c.

"By whatever substance extracted, its properties are the same;

ſame; but it is obtained in the greateſt quantity by means of metals. There are ſome, however, by means of which you extract only azotic gas, becauſe they ſeize on all the oxygen of the nitrous acid employed. The flaſk made uſe of to cauſe the acid to exerciſe an action on the metal ought to be entirely filled with the former, becauſe, if any air were left in, the gas in diſengaging itſelf would combine with the oxygen of the pure air, and this combination, diſſolving in the liquor, would occaſion a vacuum which would permit the water of the tub to paſs into the flaſk.

"Nitrous gas is a little heavier than atmoſpheric air: its ſpecific gravity is to that of air as 105·35 is to 100, and to that of diſtilled water as 13·0179 is to 10000. A cubic inch of this fluid weighs 0·4860; and the cubic foot 1 ounce 3 drams 48 grains*.

"Nitrous gas, when very pure, is not ſoluble in water; as may be eaſily proved by agitating it in that liquid.

"It gives no ſign of acidity, as it does not redden blue vegetable colours; nor does it combine with alkalies unleſs it be mixed with air, for it then becomes acid by ſeizing on the oxygen of the air.

"Nitrous gas ſpeedily deſtroys plants and animals immerſed in it; and it extinguiſhes burning bodies, firſt making the flame aſſume a green colour.

"If nitrous gas be mixed with atmoſpheric air, it becomes red, and has the odour of nitrous acid; as may be eaſily proved by diffuſing a little of it through the air: it then abſorbs the oxygen of the air, combines with it, and becomes nitrous acid. This may be better ſhown by the following experiment:—Put two meaſures of atmoſpheric air and then one of nitrous gas into a glaſs tube marked in equal diviſions with a diamond: the mixture will immediately become red and grow hot; and as this combination, which is really nitrous acid, is very ſoluble in water, you will ſee the water aſcend in the tube in proportion as the mixture diſſolves in it, ſo that of the 3 meaſures about 1 ½ will be diſſolved, if the

* According to the new French ſyſtem, a cubic decimetre of this fluid weighs 1 gramme 301 milligrammes; and a cubic metre, 1 chiliogramme 301 grammes 335 milligrammes.

the air be of a good quality. What remains under the gaseous form is nothing but azotic gas. The heat produced on this occasion is owing to the caloric of these fluids, which assumes the free state. If, instead of atmospheric air, you mix pure air with the nitrous gas, *viz.* two measures of gas and one of pure air, the redness will be much more intense, the heat produced far greater, and the mixture will be almost entirely dissolved in the water.

" It may be here seen, that by means of this gas we can ascertain the salubrity of the air; for it combines only with oxygen, or the base of pure air, which is the only respirable part of the atmosphere. Air subjected to this test ought therefore to be considered as so much fitter for respiration, according as the quantity of it absorbed is greater.

" The water in which this mixture of nitrous gas and pure air is dissolved, becomes liquid nitrous acid; so much the stronger the less it contains of water. 1st, It reddens blue vegetable colours; it is therefore acid: 2d, This acid unites and combines with alkalies, and forms with them detonating nitres: it is therefore nitrous acid. To prove this, affix to the bottom of a bell-glass some concrete carbonat of ammonia tied up in a small piece of gauze, and place the bell on the shelf of a pneumatic tub in such a manner that the bell may be two-thirds filled with atmospheric air, while the other third contains water. If you then make nitrous gas to pass into the bell, the mixture will immediately assume a red colour: an effect produced by the combination of the gas with the respirable part of the air. By this combination the gas has become nitrous acid. You will then perceive a great deal of white vapours arising from the combination of this acid with the carbonat of ammonia. These vapours are afterwards condensed, and crystallise. The crystals collected will fuse on burning coals, and therefore are nitre.

" *Oxygenated Muriatic Gas.*

" Oxygenated muriatic gas, the dephlogisticated muriatic acid of Scheele under a gaseous form, is the muriatic acid gas, of which we shall speak hereafter, but surcharged with oxygen and perfectly dephlegmated.

8 " This

"This gas is obtained by expofing the muriatic acid to heat and evaporation while it is acting on a fubftance that contains oxygen; fuch, for example, as the native oxyd of manganefe. If you therefore put 50 parts of the native oxyd of manganefe and 100 parts of muriatic acid into a glafs retort, and expofe it to heat, a ftrong fermentation will be excited, during which the muriatic acid will be converted into gas, but furcharged with oxygen which it takes from the oxyd of manganefe, becaufe it has a great affinity for that fubftance. To collect this gas, when you have reafon to think that all the air in the retort has paffed over, introduce the beak of it below a bell filled with mercury or water; for this gas does not diffolve in water but in a fmall quantity, and when the water is faturated with it, the excefs of the gas will pafs into the upper part of the bell.

"This gas, then, is compofed of muriatic acid gas and an excefs of oxygen. It is this oxygen in excefs which, though it be the acidifying principle, deprives it of the whole, or nearly the whole, of its acidity, and renders it lefs foluble in water. This is a fact difficult to be explained. We have have already faid that an excefs of oxygen added to nitrous gas produces in it a contrary effect; for it gives it an acidity it did not before poffefs, and renders it perfectly foluble in water. It would be difficult to account for thefe different effects, but they are facts well attefted, which we ought to adopt though ignorant of the caufe.

"Oxygenated muriatic gas is not invifible like the other gafes; it is of a greenifh-yellow colour, which renders it very perceptible. It has a ftrong pungent odour, and is dangerous to infpire, becaufe it excites a violent cough, and might occafion a hæmorrhage.

"We have before mentioned that oxygenated muriatic gas is not acid, or at leaft very little fo: a proof of this is, that it does not combine, or at leaft very little, with alkalies; and that it has not force fufficient to drive the carbonic acid from the different bafes with which it is combined: an effect produced by all the known acids, however weak; befides, it does not redden blue vegetable colours, as it would do if it were acid. It however deftroys not only blue, but alfo all

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the other vegetable colours, and converts them into white. It deprives all flowers of their colour, and bleaches cloth, yellow wax, silk, &c. It is by means of its excess of oxygen that it produces these effects; and by losing its excess of oxygen it returns to the state of simple muriatic acid gas, which is then entirely soluble in water.

"Oxygenated muriatic gas extinguishes burning bodies, and speedily destroys animals immersed in it.

"This gas has the property of decomposing ammonia: its excess of oxygen combines with the hydrogen of the ammonia (which is composed of one part of hydrogen and six of azot), and forms water, while the azot is left free.

"Oxygenated muriatic gas is not so soluble in water as the plain muriatic acid gas, which can in no manner be collected over water: it is, however, soluble in it to a certain degree, and then forms liquid *oxygenated muriat*, which is the real solvent of gold, platina, &c. as may be proved by putting into that liquor some gold leaf, which will be speedily dissolved.

"In the nitro-muriatic acid it is the agent that dissolves gold, for that acid is a mixture of muriatic acid and nitric acid. In this mixture the muriatic acid, the radical of which has a great affinity for oxygen, combines with the oxygen of the nitric acid, and, by these means, becomes oxygenated muriat, and the base of the nitric acid remains free; so that in this liquor no more acid perhaps is left. The nitric acid has lost its acidity by losing its oxygen, and the muriatic acid has lost its acidity by combining with the oxygen of the nitric acid. These are two facts which, as already said, are difficult to be explained.

"The oxygenated muriat is gradually decomposed by the contact of light which disengages its excess of oxygen. By losing this excess of oxygen it passes to the state of pure muriatic acid; and the oxygen thus disengaged combining with caloric, forms pure air, called *oxygen gas.*"

*An Epitome of Chemistry. By* William Henry. *Small* 12*mo.* Johnson, St. Paul's Church-Yard.

THIS valuable little volume is divided into three parts. Part I. intended to facilitate to the student the acquisition of of chemical knowledge by minute inſtructions for the performance of experiments.—Part II. Directions for the analyſes of mineral waters, of earths and ſtones, of ores of metals, and of mineral bodies in general.—Part III. Inſtructions for applying chemical teſts and re-agents to various uſeful purpoſes. The plan and objects of the work, as the author himſelf obſerves, are ſufficiently diſtinct from every other compendium of chemiſtry to authoriſe its addition to the extenſive liſt of elementary works. One object propoſed to be fulfilled by this epitome is, "that it may ſerve as a companion to the collections of chemical ſubſtances, which the author, by the repeated applications of ſtudents of this ſcience, has been induced to fit up for public ſale. The utility of theſe collections has hitherto been limited by the want of a conciſe but comprehenſive code of inſtructions for their uſe. With the concurrent aid of the firſt part of this work, and of a correſponding cheſt of chemical re-agents, the labours of the ſtudent cannot fail to be much facilitated; for one of the principal difficulties in ſtudying chemiſtry experimentally, is the acquiſition of a great variety of ſubſtances, many of which are not eaſy of attainment."

The following extracts reſpecting the methods for aſcertaining the purity of chemical preparations, &c. are from Part III.

*Acetic Acid—Acidum Acetoſum of the London Pharmacopœia. Radical or concentrated Vinegar.*

"This acid is often contaminated by ſulphureous and ſulphuric acid. The firſt may be known by drawing a little of the vapour into the lungs, when, if the acid be pure, no unpleaſant ſenſation will be felt; but, if ſulphureous acids be contained in the acetic, it will not fail to be diſcovered in this mode. The ſulphuric acid is detected by muriated barytes; copper by ſuper-ſaturation with pure ammonia; and lead by ſulphuret of ammonia.

"The ſpecific gravity of this acid ſhould be 1050 at leaſt.

"*Acetous Acid—Acetum Diſtillatum, P. L. Diſtilled Vinegar.*

"If vinegar be diſtilled in copper veſſels, it can hardly fail

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being contaminated by that metal; and if a leaden worm be used for its condensation, some portion of lead will certainly be dissolved. The former metal will appear on adding an excess of solution of ammonia; and lead will be detected by the sulphurated ammonia, or by water saturated with sulphurated hydrogen.

"It is not unusual, in order to increase the acid taste of vinegar, to add sulphuric acid. This acid may be immediately discovered by solutions of barytes, which, when vinegar has been thus adulterated, throw down a white precipitate."

"*Carbonat of Potash—Kali Preparatum, P. L.*

"The salt of tartar of the shops generally contains sulphat and muriat of potash, and siliceous and calcareous earths. It should dissolve entirely, if pure, in twice its weight of cold water; and any thing that remains undissolved may be regarded as an impurity. Sometimes one-fourth of foreign admixtures may thus be detected, the greater part of which is sulphat of potash. To ascertain the nature of the adulteration, dissolve a portion in pure and diluted nitric acid. The siliceous earth only will remain undissolved. Add, to one portion of the solution, nitrat of barytes. This will detect sulphat of potash by a copious precipitate. To another portion add nitrat of silver, which will discover muriatic salts; and, to a third, oxalat of ammonia, which will detect calcareous earth.

"The solution of carbonat of potash (Aqua Kali, P. L.) may be examined in a similar manner.

"*Solution of pure Potash—Aqua Kali Puri, P. L.*

"This may be assayed for sulphuric and muriatic salts by saturation with nitric acid, and by the tests recommended in speaking of carbonat of potash. A perfectly pure solution of potash should remain transparent, on the addition of barytic water. If a precipitate should ensue, which dissolves, with effervescence, in dilute muriatic acid, it is owing to the presence of carbonic acid; if the precipitate is not soluble, it indicates sulphuric acid. A redundancy of carbonic acid is also shown by an effervescence on adding diluted sulphuric acid;

acid; and an excess of lime, by a white precipitate, on blowing air, from the lungs, through the solution, by means of a tobacco-pipe."

"*Mercury or Quicksilver—Hydrargus,* P. L.

"Scarcely any substance is so liable to adulteration as mercury, owing to the property which it possesses of dissolving completely some of the baser metals. This union is so strong, that they even rise along with the quicksilver when distilled. The impurity of mercury is generally indicated by its dull aspect; by its tarnishing, and becoming covered with a coat of oxyd on long exposure to the air, by its adhesion to the surface of glass; and, when shaken with water in a bottle, by the formation of a black powder. Lead and tin are frequent impurities; and the mercury becomes capable of taking up more of these, if zinc or bismuth be previously added. In order to discover lead, the mercury may be agitated with a little water, in order to oxydate that metal. Pour off the water, and digest the mercury with a little acetous acid. This will dissolve the oxyd of lead, which will be indicated by a blackish precipitate with sulphurated water. Or, to this acetous solution, add a little sulphat of soda, which will precipitate a sulphat of lead, containing, when dry, 72 per cent. of metal. If only a very minute quantity of lead be present in a large quantity of metal, it may be detected by solution in nitric acid, and the addition of sulphurated water. A dark brown precipitate will ensue, and will subside, if allowed to stand a few days. One part of lead may thus be separated from 15,263 parts of mercury. Bismuth is detected by pouring a nitric solution, prepared without heat, into distilled water; a white precipitate will appear, if this metal be present. Tin is manifested, in like manner, by a weak solution of nitro-muriat of gold, which throws down a purple sediment; and zinc, by exposing the metal to heat."

"*Mode of detecting the Adulteration of Potashes, Pearlashes, and Barilla.*

"Few objects of commerce are sophisticated to a greater extent than the alkalies, to the great loss and injury of the bleacher, the dyer, the glass-maker, the soap-boiler, and of all other artists who are in the habit of employing these substances. In the first part of this work I have already given rules for discovering such adulterations; and to what has been said, I apprehend it is only necessary to add the directions of Mr. Kirwan, intended to effect the same end, but differing in the mode. They are transcribed from his paper entitled 'Experiments on the Alkaline Substances used in Bleaching.'—See Transactions of the Irish Academy for 1789.

" To discover whether any quantity of fixed alkali worth attention exists in any saline compound, dissolve one ounce of it in boiling water, and into this solution let fall a drop of a solution of sublimate corrosive; this will be converted into a brick colour, if an alkali be present, or into a brick colour mixed with yellow, if the substance tried contains lime.

" But the substances used by bleachers being always impregnated with an alkali, the above trial is in general superfluous, except for the purpose of detecting lime. The quantity of alkali is therefore what they should chiefly be solicitous to determine, and for this purpose,

" 1st. Procure a quantity of alum, suppose one pound, reduce it to powder, wash it with cold water, and then put it into a tea-pot, pouring on it three or four times its weight of boiling water.

" 2dly. Weigh an ounce of the ash or alkaline substance to be tried, powder it, and put it into a Florence flask with one pound of pure water (common water boiled for a quarter of an hour, and afterwards filtered through paper, will answer), if the substance to be examined be of the nature of barilla, or potash; or half a pound of water if it contain but little earthy matter, as pearl-ash; let them boil for a quarter of an hour: when cool, let the solution be filtered into another Florence flask.

" 3dly. This being done, gradually pour the solution of alum, hot, into the alkaline solution also heated; a precipitation will immediately appear; shake them well together, and let the effervescence, if any, cease before more of the aluminous solution be added: continue the addition of the alum until the mixed liquor, when clear, turns syrup of violets, or paper tinged blue by radishes, or by litmus, red; then pour the liquor and precipitate on a paper filter placed

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in a glafs funnel. The precipitated earth will remain on the filter; pour on this a pound or more of hot water gradually, until it paffes taftelefs: take up the filter, and let the earth dry on it until they feparate eafily. Then put the earth into a cup of Staffordfhire ware, place it on hot fand, and dry the earth until it ceafes to ftick to glafs or iron; then pound it, and reduce it to powder in the cup with a glafs peftle, and keep it a quarter of an hour in a heat of from 470° to 500°.

"4thly. The earth being thus dried, throw it into a Florence flafk, and weigh it; then put about one ounce of fpirit of falt into another flafk, and place this in the fame fcale as the earth, and counterbalance both in the oppofite fcale: this being done, pour the fpirit of falt gradually into the flafk that contains the earth; and when all effervefcence is over (if there be any) blow into the flafk, and obferve what weight muft be added to the fcale containing the flafks to reftore the equilibrium; fubtract this weight from that of the earth, the remainder is a weight exactly *proportioned* to the weight of mere alkali of that particular fpecies which is contained in one ounce of the fubftance examined; all befide is fuperfluous matter.

"I have faid that alkalies of the *fame fpecies* may thus be directly compared, becaufe alkalies of *different* fpecies cannot but require the intervention of another proportion; and the reafon is, becaufe *equal* quantities of alkalies of different fpecies precipitate *unequal* quantities of earth of alum. Thus 100 parts, by weight, of mere *vegetable* alkali precipitate 78 of earth of alum; but 100 parts of *mineral* alkali precipitate 170,8 parts of that earth. Therefore the precipitation of 78 parts of earth of alum by vegetable alkali denotes as much of this as the precipitation of 170,8 of that earth by the mineral alkali denotes of the mineral alkali. Hence the quantities of alkali in all the different fpecies of pot-afhes, pearl-afhes, weed or wood-afhes, may be immediately compared by the above teft, as they all contain the vegetable alkali; and the different kind of kelp or kelps manufactured in different places, and the different forts of barilla, may thus be compared, becaufe they all contain the mineral alkali. But kelps and pot-afhes, as they contain different forts of alkali, can only be compared together by means of the proportion above indicated."

[To be continued.]

XXXIV.

## XXXIV. *Proceedings of Learned Societies.*

### ROYAL SOCIETY OF LONDON.

AT the meeting of this learned body, on the 26th of March, there was read an hiſtorical and anatomical account of a dubious amphibious animal, only found in a ſmall lake in Carniola: by M. Schrader.

On account of Paſſion and Eaſter weeks there were no meetings on the 2d and 9th of April.

On the 17th the account of the animal was concluded, and the reading of a paper, by Dr. Herſchel, containing obſervations on the nature of the ſun, was commenced, and was continued on the 23d, but not then concluded. The Doctor ſays that continued obſervations have confirmed him in his opinion that the ſun is a magnificent habitable world, and gives this paper as a more comprehenſive view of the ſubject than the one formerly laid before the Society, (ſee Philoſophical Magazine, Vol. V.) and ſuch as a ſeries of obſervations with an improved reflector has enabled him to make; obſervations which, the Doctor conceives, will be of utility in future meteorological reſearches. The names already in uſe for the ſolar phænomena he objects to, as conveying no meaning; ſuch as ſpots, maculæ, faculæ, penumbræ, &c.; and wiſhes to ſubſtitute for them, openings, flats, krancles, ridges, nodules, dimples, punctures. The openings are what were denominated ſpots, and he conceives are cauſed by an elaſtic but not a luminous gas being diſengaged from the ſun and driving away the luminous fluid, which enables us to behold his body. Flats are what are uſually called penumbræ, and are depreſſions below the general ſurface of the ſun, but not ſo deep as the body of it. Krancles are irregular elevations and depreſſions which cover the whole diſk of the ſun. Ridges are elevations above the general ſurface of the ſun: ridges generally accompany openings. This paper contains many moſt curious obſervations on the alterations and paſſing into one another of theſe appearances; but as the reading of the paper is not yet finiſhed, we forbear ſtating any more at preſent.

## ROYAL INSTITUTE OF GREAT BRITAIN.

It muſt give pleaſure to our readers to learn that this new and uſeful inſtitution, the object of which is the application of ſcience to the common purpoſes of life, may be now conſidered as ſettled on a firm baſis. The lectures of Dr. Garnett have been ſuch as to do equal honour to the inſtitution and the profeſſor, and have been well attended.

We have alſo to notice a courſe of lectures, juſt commenced at the inſtitution, on a new branch of philoſophy—we mean the Galvanic phænomena. On this intereſting branch Mr. Davy (late of Briſtol) gave the firſt lecture on the 25th of April. He began with the hiſtory of Galvaniſm, detailed the ſucceſſive diſcoveries, and deſcribed the different methods of accumulating galvanic influence. Poliſhed plates of different metals, and the effect of their lying together in contact with water and air, were exhibited. Air is abſolutely neceſſary to the oxydating proceſs. He obſerved that it was difficult to prove that hydrogen was given out in the decompoſition of water in this way, and that it ſeemed rather probable that alkali was formed. He ſhowed the effects of galvaniſm on the legs of frogs, and exhibited ſome intereſting experiments on the galvanic effects on the ſolution of metals in acids.

By ſome recent experiments of this ingenious chemiſt it appears, that with one kind of metal only, more powerful effects may be produced than with two as heretofore employed; but in this caſe there muſt be more than one liquid interpoſed between the plates. Mr. Davy ſtates that copper, for example, and diſcs of cloth or paſteboard moiſtened with diluted nitrous acid, and ſolutions of muriat of ſoda and ſulphuret of potaſh, (and arranged in the order in which we have named them, viz. copper, nitrous acid, muriat of ſoda, ſulphuret of potaſh, copper, nitrous acid, &c.) give much more ſenſible ſhocks than the pile as at firſt conſtructed.

Sir Joſeph Banks, Count Rumford, and other diſtinguiſhed philoſophers were preſent. The audience were highly gratified, and teſtified their ſatisfaction by general applauſe. Mr. Davy, who appears to be very young, acquitted himſelf admirably well: from the ſparkling intelligence of his eye, his animated manner, and the *tout enſemble*, we have no doubt of his attaining a diſtinguiſhed eminence.

The ſecond lecture was given on the 28th, and the others, to the number of five in all, are to be delivered on the Tueſday and Saturday evenings till completed.

BRITISH MINERALOGICAL SOCIETY.

This uſeful body has lately circulated the following notice: "*To Farmers and Perſons engaged in Experiments on Agriculture.*

"The immenſe importance which, at all times, and particularly at preſent, is attached to improvements in agriculture, and the liberal encouragement to experiments in the art of cultivating the land offered by the patriotic views of the Board of Agriculture, have rendered it a deſirable object to aſſiſt the inquiries of the farmer in that part of experimental chemiſtry which determines the nature of ſoils by an analyſis of their ſeveral contents.

"The Britiſh Mineralogical Society, having of late increaſed the number of their members, find themſelves enabled to extend the plan of their inſtitution, from the analyſis of *minerals*, in the uſual ſenſe of the term, to that of the various ſoils which are made the baſis of agricultural operations.

"They therefore give this public notice that they will examine, free of expenſe, all ſpecimens of earths or ſoils, with a view of determining the nature and proportion of their different contents, with as much accuracy as ſhall ſeem requiſite.

"They require, however, that the perſons ſending ſpecimens ſhall comply with the following conditions:

"That the ſpecimen be about three or four pounds in weight, incloſed in a deal box properly packed with hay, and along with it an account be added of the pariſh and county from which it is procured, the name of the ſender and his addreſs per poſt, and an anſwer to the following queries——What is the depth of the ſoil?—What the nature of the ſub-ſoil? is it on a hill or level ground? and, if the former, what is the aſpect?—how near to any river or

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ſtream?—and is the ſoil itſelf dry or ſpringy?—what is the rotation of crops which it uſually bears?—has it ever been limed or had any other earth laid on?——Any other particulars worthy of notice may alſo be added, and a ſpecimen of the ſub-ſoil ſhould alſo be incloſed.

"Before the ſpecimen is packed up, it ſhould be gently dried, either in the ſun or in any warm place, for a few days, but muſt on no account be heated over a fire.

"The box containing the ſpecimens muſt be ſent, *carriage paid*, to Mr. W. H. PEPYS Jun. No. 24, Poultry, London.

"The Society intend, if conſiſtent with their other occupations, to return the reſult of the analyſis within two months of the arrival of the ſpecimen."

"London, April 16, 1801."

## TEYLER'S SECOND SOCIETY AT HAARLEM.

This ſociety has propoſed the following prize ſubject:

A view or delineation ſupported by ſufficient proofs and illuſtrations of what peculiarly characteriſes the eighteenth century in regard to improvements in ſcience and morals in compariſon of preceding centuries. The ſociety requires that, agreeably to what has been formerly announced, the candidates will examine and point out whether the principal nations of Europe during the eighteenth century have made any progreſs in the above reſpect? Should this be anſwered in the affirmative, it is required to know in what this progreſs conſiſts? If anſwered in the negative, to what cauſes is this want of progreſs to be aſcribed? The ſociety conſequently requires to know: Whether, and how far in general, that part of mankind whoſe hiſtory is beſt known have advanced in real knowledge and moral improvement.

The ſociety promiſes to the perſon who ſhall ſend the beſt anſwer to theſe queſtions before the 1ſt of April 1802, a golden medal of the value of 400 florins.

The ſociety alſo renews the prize queſtion for the year 1799, reſpecting the aqueous phænomena of the atmoſphere, no ſatisfactory anſwer to which has been yet received, and promiſes for the beſt anſwer ſent in before the ſame period, a like prize of 400 florins. This queſtion is as follows:

As it is of the greateſt importance to every branch of natural philoſophy, that the preſent ſtate of our knowledge reſpecting them ſhould be clearly explained, and that every thing proved by experiment ſhould be carefully ſeparated from what is ſupported only by hypotheſis, the ſociety requires to know:

What is the preſent ſtate of our knowledge in regard to aqueous phænomena?—How far can we aſcertain from well authenticated experiments the cauſes by which water is received into the atmoſphere and retained there in the form of vapour or in any other manner?—And to what cauſes is it to be aſcribed that the water retained in the atmoſphere is ſet at liberty and falls down under various forms?—Can the aqueous phænomena be aſcribed to the liberation of the water retained in the atmoſphere alone? or are there any obſervations which clearly ſhow that, during ſome aqueous phænomena, water is produced in the atmoſphere?

The ſociety renews alſo the following queſtion, to which no ſatisfactory anſwers have been received, and offers a gold medal of the value of 400 florins for the beſt anſwer tranſmitted to the ſociety before the 1ſt of April 1802:

What do we know with certainty reſpecting the nouriſhment and growth of plants? or how far can we determine, from deciſive and well-authenticated experiments, thoſe ſubſtances or matters which ſerve in particular as the pabulum of plants, and the manner in which they receive, ſecrete, and aſſimilate them?—How much of the information given us on this head by eminent naturaliſts is ſtill to be conſidered as doubtful?—By what experiments might our knowledge on this ſubject be enlarged or confirmed? and what information does our actual knowledge of the growth and nouriſhment of plants ſupply us with to enable us to raiſe and tranſplant with more ſucceſs uſeful vegetables in different kinds of ſoil?

The ſociety requires, in particular in regard to the two firſt members of this queſtion, that the candidates will give an accurate account of the preſent ſtate of this part of the natural hiſtory of plants, and at the ſame time make a diſ-

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tinction between what is doubtful and what has been fully proved. By these means this part of the question can be answered in a satisfactory manner, though the branch of natural history to which it belongs may not be enriched with new discoveries.

The candidates are requested to turn their attention to the latest writers on this subject, in which many hints will be found to direct them in their researches, such as F. A. Von Humboldt's Aphorisms, in regard to the Chemical Physiology of Plants, *Leipsic* 1794, 8vo.; and C. G. Rafn's Sketch of a Physiology of Plants, *Leipsic* 1798, 8vo.

The answers to all these questions must be written in Dutch, French, English, or German, but not in German characters, and transmitted, in the usual manner, with a sealed note containing the author's name, to Teyler's Institute at Haarlem, before the 1st of April 1802, that the prizes may be adjudged on the 1st of November the same year.

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## XXXV. *Miscellaneous Articles.*

### METEOROLOGY.

THE following curious notice has lately been published in one of the foreign journals by Schweighauser:—" A prelate in the neighbourhood of Bâle, having extended in his garden an iron wire of considerable length for the purpose of suspending from it a moveable mark to fire at, observed that, during variations of the atmosphere, which modified a change of weather, the wire emitted a stronger or weaker sound, according to the nature of these changes. He communicated this observation to Mr. Haas, who had come to see him, and who, on his return to Bâle, having caused a similar wire to be extended in his garden, observed the same phænomenon. Some time after, the celebrated Volta, when on a visit to Haas, saw this new kind of barometer, and, in order to ascertain the nature of the meteoric humming it emitted, extended wires of different metals in different directions; but found that no vibration took place, except in regard to those wires

wires extended in the direction of the meridian. Volta, in consequence of this peculiarity, ascribed the phænomenon to the magnetic fluid, and speaks of it in his works. I do not, however, know that this new effect of a fluid so universally diffused has been sufficiently examined.

"Mr. Haas jun. informed me that the wires ought at least to be a hundred feet in length (those of his father were about three hundred), and that they must be stretched as much as possible: they do not sound till they have been exposed to the air for several weeks. Mr. Haas sen. had extended, for some time, fourteen, of different sizes, which emitted sometimes very agreeable sounds."

Humboldt at Caraccas, in South America, has made some interesting observations on the motion of the barometer near the equator. "I have read," says he, "in the Transactions of the Bengal Society, that the barometer rises and falls there regularly every twenty-four hours. Here, in South America, its motion is more astonishing. There are four atmospherical tides every twenty-four hours, which depend only on the attraction of the sun. The mercury falls from 9 o'clock in the morning till 4 o'clock in the evening. It rises from 4 till 11 o'clock; it falls from 11 o'clock till half past 4 in the morning; it reascends from that time till 9 o'clock: neither winds, storms, nor earthquakes, have any influence on this motion." This fact goes a great way towards proving the general truth of Mr. Howard's theory, given in the Philosophical Magazine, Vol. VII.

## GASEOUS OXYD OF CARBON.

This name is given, by Mr. Cruickshank, of Woolwich, to the inflammable gas liberated from a mixture of forge-scales of iron and charcoal, the production of which has been held by Dr. Priestley as a proof of the truth of the phlogistic theory, as water could not be supposed present to assist in producing the gas by being decomposed.

If scales of iron and charcoal, both previously ignited to drive off every kind of moisture, be introduced into a coated glass retort, or into an iron one, and the retort be exposed, connected

connected with a pneumatic apparatus, to a red heat, a quantity of a gas comes over which burns in a manner similar to the hydrocarbonats. It consists of about one part of carbonic acid and six parts of a species of inflammable gas which Dr. Priestley considers as a species of hydrocarbonat.

A mixture of gray oxyd of iron (forge-scales) and carbonat of barytes by similar treatment gives also an inflammable gas, which Mr. Cruickshank finds to consist of carbonic acid gas $2\frac{1}{2}$ parts, and gaseous oxyd of carbon one part.

Mr. Cruickshank obtained a similar gas from mixtures of charcoal and sublimed oxyd of zinc, red oxyd of copper, litharge, manganese; and concludes, that all metallic oxyds capable of enduring a red heat, being treated with charcoal, will yield not only carbonic acid but a species of inflammable gas; that the oxyds which retain their oxygen most obstinately yield most inflammable gas, and those which part with it readily most carbonic acid. The latter comes over chiefly at the beginning, and the inflammable gas towards the conclusion of the process.

Mr. Cruickshank, having repeatedly washed this inflammable air with lime water to separate the carbonic acid, found it to be only a very little lighter than common air, that is to say, in the proportion of about 22 to 23; the common hydrocarbonats are not more than half that weight. Having endeavoured to estimate the quantity of pure oxygen necessary to saturate it, after several trials he found that four measures of it and two of oxygen, exploded in a strong glass jar over mercury by means of the electric spark, were reduced to $3\frac{1}{2}$, which by agitation with lime water were proved to be carbonic acid, except about $\frac{1}{4}$ of a measure which, by the nitrous test, was pure oxygen: hence it would appear that eight measures of the gas require $3\frac{1}{2}$ measures of pure oxygen gas to saturate them, and produce by their combination six measures of carbonic acid gas* with a little water. Six measures of carbonic acid gas require for their production at least seven measures of pure oxygen instead of $3\frac{1}{2}$, the quantity made use

* Hydro-carbonats mixed with oxygen and exploded, are increased in volume instead of being diminished, as is the case with this gaseous oxyd.

of

of in the present case; and therefore Mr. Cruickshank infers, with justice, that the other $3\frac{1}{2}$ must have been originally combined with the gas, constituting it a gaseous oxyd; and hence it appears that this gas bears the same relation to carbonic acid, that nitrous gas does to the nitrous acid.

This gaseous oxyd seems to owe its origin to a decomposition of carbonic acid at a high temperature; for it may be obtained from a mixture of iron filings and carbonat of lime instead of gray oxyd and charcoal, and in more abundance. Twenty parts of the gas so obtained, freed from carbonic acid, mixed with eight parts of oxygen, and fired over mercury by the electric spark, the whole was reduced to 18 or 19 parts, which were found to be carbonic acid, being totally absorbed by lime water; it contains neither water nor the basis of water: that obtained by means of charcoal yields water, owing to the hydrogen which enters more or less into the composition of all common charcoal.

None of the known hydrocarbonats are similar in their properties to the gaseous oxyds of carbon, being much lighter and yielding a far less proportion of carbonic acid when combined with oxygen. They consist of carbonic acid united with or held in solution by hydrogen; but the gaseous oxyds are nothing but carbon united with or held in solution by oxygen, and rendered gaseous by caloric. In their production from a metallic oxyd the metal is found revived, its oxygen having gone into the composition of the gaseous oxyd and acid; and from their production by the decomposition of the same acid, (as when chalk and iron filings are employed) it would appear that carbonic acid, when at a high temperature, may be decomposed by any fixed substance which has a strong affinity for oxygen. Thus the objections to the new system of chemistry advanced on this head by Dr. Priestley seem to have been sufficiently answered by Mr. Cruickshank; and the presence of hydrogen or water seems by no means necessary to the production of these gaseous oxyds *.

* Those who wish to peruse a full account of Mr. Cruickshank's interesting experiments on this subject, are referred to Mr. Nicholson's Journal, Vol. V. April 1801.

## XXXVI. *Observations on Mosaic, and the most celebrated Works of that Kind, both antient and modern**.

MOSAIC is a kind of painting by means of small bits of glass, stone, wood, enamel, and other substances of different colours, cemented to some surface by some sort of mastic, and which may be executed in such perfection that at a little distance a common eye would take it for real painting. The common name mosaic comes from the Italian *musaïco*, derived from the Greek word *musakion*, used in the lower ages to denote those kinds of works called in Latin *musivum*.

Though this kind of painting was very common among the antients, Pliny speaks neither of works in mosaic nor of artists who exercised it. We cannot judge, therefore, of the mechanism of the art but from the manner in which it is executed by the moderns, and from the antient monuments of this kind which have been preserved. To construct works in mosaic, the artist first forms a ground of flat stones, bordered with bands of iron and surrounded with a solid rim of stone. This ground is covered with thick mastic, in which the coloured pieces of glass, stone, &c. are implanted according to the design traced out on the ground; and during his labour the artist has before him the painting he intends to copy. This mastic acquires the hardness of stone, and when the whole has sufficient consistence it is polished in the same manner as glass. As the splendour, however, which mosaic then acquires prevents the design from being accurately distinguished, large works intended to be viewed at a distance, such as those placed in ceilings, cupolas, &c. are not polished. The art has been discovered of giving to the colour of the glass as many different shades as are necessary for executing paintings of every kind. The artist in mosaic, while at work, has the pieces of glass, marble, &c. ranged in cases according

* From *Magazin Encyclopédique*, Vol. VI. No. 22.

to their different shades, like a printer's types. The art of making mosaics in relief is said to have been invented, several years ago, by Pompeo Savini, of Urbino. Archenholz, in his Picture of Italy, asserts, however, that no work of importance was ever executed according to this method. Some have also tried to saw through mosaic works in a transversal direction, in order to multiply them. According to Björnstahl, in the second volume of his Travels, Pompeo Savini was the first person who tried this method at Rome. It appears that pavements in coarse mosaic, executed among the antients, were not made at the same period as those of more delicate workmanship. The place where it was necessary to implant the mosaics were in the former left more delicately terminated. Thus at Herculaneum, according to Winkelman, there was found, in the middle of a coarse mosaic pavement, a portion of mosaic of more delicate workmanship, which did not adhere to the rest, and which only had a relation to it.

It appears that the origin of mosaic ought to be ascribed to the different compositions of hard stones employed by the orientals as ornament, and of which we find a striking example in the ornaments of the high-priest among the Jews. It is observed in general that all nations among whom civilisation has made little progress are fond of splendid and variegated colours: we find, therefore, that mosaic was in great esteem during the first centuries of the French monarchy, as is proved by the mosaics with which Clovis caused the church of St. Peter and St. Paul, at present that of Sainte-Genevieve, and the tomb of Fredegonda, to be ornamented; and hence it became usual to cover surfaces with coloured bodies according as their figures permitted them to be joined, and to ornament buildings, pavements, ceilings, &c. with stones of different colours. It is probable that the Persians, Babylonians, and other people of the East, whose countries abounded with hard stones, were acquainted with this kind of embellishment. They displayed a considerable degree of ingenuity in executing flowers, animals, &c. by the combination of pieces of stone of different colours: this was the extent of their art; but it was the Greeks who introduced into this process that taste and perfection which entitle it to

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the appellation of an art. These people, indeed found means to manage the shades with so much dexterity, and to give to the figures and groups which they executed such order and harmony, that at a distance they resembled paintings.

This art was conveyed from the Greeks to the Romans. Sylla was the first among the latter who caused to be executed in the temple of Fortune at Præneste, at present called Palæstrina, a mosaic, great part of which still exists. At first the pavements of buildings only were ornamented in this manner, but afterwards walls and arched ceilings. Portable floors for the tents of princes and the commanders of armies, in order to guard against moisture, were ornamented also in the same manner. The invention of coloured glass gave to this art a greater degree of perfection. This material, in particular, was employed in the time of Augustus. But pieces of glass or marble were still of too large size to admit of the shades being properly blended, and consequently of giving the natural colour to the objects. Under Claudius the Romans began to colour marble, and under Nero to give it spots by an artificial process.

In the fifth century, when the arts were expelled from Italy by the invasions of the barbarians, mosaic painting and sculpture were preserved much longer among the Greeks of Byzantium for ornamenting the altars and utensils of the church. Mosaic, however, lost at Constantinople, as the other arts did, that character of elevation which characterizes the monuments of Grecian art: besides, works of this kind were executed with pearls and precious stones, whereas the antient Greeks preferred marble for mosaic. Towards the end of the 13th century an Italian, named Andrew Tassi, learned the art of mosaic from one Apollonius, a Greek, who decorated with it the church of St. Mark, at Venice, where an excellent pavement by him is still to be seen. But in general these works want design, are in a bad taste, and, besides, have a bad colour. Since that period this art has been carried to a high degree of perfection in Italy. Pope Clement VIII. contributed greatly to this improvement in the 17th century, by causing all the interior part of the cupola of the church of St. Peter to be ornamented with mosaic.

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Among the artists employed for this purpose the most distinguished were Paul Rossetti and Francis Zucchi. These ornaments were finished in 1603. In the same century John Baptist Calandra, of Vercelli, in Piedmont, who was born in 1586 and died in 1644, invented a new mastic, which greatly contributed to bringing the art to perfection. During fourteen years he executed mosaics for the church of Saint Peter at Rome, and particularly the figures of the four fathers of the church in the cupola, after paintings by Lanfranchi, Sacchi, Romanelli, and Pellegrini. He copied also the picture of the archangel Michael, by Joseph Cesari; but he gave it too fine a polish, so that it has too much reflection. Afterwards various artists in mosaic endeavoured to give faithful copies of the finest paintings; such as that of the martyrdom of St. Petronilla, by Guerchin, in the church of St. Peter at Rome; the death-bed communion of St. Jerome, by Domeniquin, formerly in the church of Santo Girolamo della Carita at Rome, but now in the Musæum of the Arts at Paris. The person, however, who carried this art to its highest degree of perfection was Peter Paul de Christophoris, who founded at Rome a school of mosaic in the commencement of the 18th century. He formed several distinguished pupils, among whom were Brughio, Conti, Coccei, Fattori, Gossone, and Ottaviano. Alexis Matthioli found out, in 1730, the art of making glass of a bright red colour. In modern times mosaic has been distinguished into two kinds: that of Rome, in which stones of a very small size are employed, which gives to works more delicacy and variety, and admits the execution of great historical paintings. In this manner the most beautiful paintings of Raphael have been copied; and Clement VIII. caused the cupola of the church of St. Peter to be decorated with mosaic of the same kind. His successors continued to cause other paintings, both in oil and in fresco, to be copied. According to Björnstahl, the number of shades found in these mosaics sometimes exceeds 10,000. In the palace Borghese at Rome there are six beautiful mosaics, one of which represents Orpheus surrounded by animals: it is said to be composed of 9000 pieces. The mosaic of Florence, called by the Italians *commesso*, is executed with larger stones,

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and is employed for copying paintings of less size. The best works of this kind are in the chapel of the grand duke at Florence. Several beautiful mosaics of this kind are now in the Musæum of the Arts at Paris.

One of the greatest advantages of mosaic is its resistance to every thing that generally alters the beauty of fine paintings, and the facility with which it may be cleaned, by giving it a new polish without any danger of destroying the colours. As mosaic, however, can be executed only in a slow manner, and as it requires considerable expense, it never can be brought into such general use as painting; it would never even have attained at Rome and Florence to that degree of perfection to which it was carried, had not the governments of these two countries defrayed the expenses.

In modern times very beautiful mosaics in wood, known in England by the name of *inlaying*, in France by that of *marqueterie*, and in Italy under that of *tausia* or *tarsia*, have been executed in different countries. Philip Bruneleschi and John de Vanone at Florence, who lived in the 15th century; John Marc, of Blois, who worked for the king of France; and Melchior Rummer, who resided near Heidelberg, distinguished themselves most in the execution of this sort of mosaic. Shell-work may be considered also as a kind of mosaic. In one of the groves of Versailles there is a master-piece of this kind. Bonavita Blank, director of the cabinet of natural history at Würzbourg, is the inventor of a new kind of mosaic, in which nothing is employed but different sorts of moss, and has been able to execute, with the greatest fidelity, landscapes, marine views, volcanoes, ruins, and buildings. The beautiful collection of this artist has been exhibited in four halls of the castle of Würzbourg since 1794, the period when it was purchased by the bishop.

The most beautiful mosaics preserved in the pavements or on the walls of antient buildings are: 1st, That found in the pavement of a chamber of the villa Hadriani, near Tivoli; it represents a vase filled with water, on the edge of which are four pigeons, one of them in the attitude of drinking. The great merit of this work consists chiefly in its being composed of small stones, while in all the other mosaics pastes of glass

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are employed to obtain those shades of colours which do not exist in stones. It belonged formerly to cardinal Furietti. It was purchased, together with some centaurs, for the sum of 13,000 scudi, by Clement XIII. who caused it to be placed in the Capitol. Furietti thought it to be the mosaic of Pergamus mentioned by Pliny: but Winkelman has shown the falsity of this opinion. This mosaic is commonly known under the name of the *four pigeons*, or the *mosaic of the Capitol.* It has been copied a great number of times, on a small scale, for snuff-boxes and medallions.—2d, The mosaic executed by the order of Sylla in the temple of Fortune at Præneste, at present Palæstrina. It was first published by Kircher, Montfaucon, and Shaw; and afterwards by the abbé Barthelemy, who made it the subject of a particular memoir, in which he establishes, that the subject it represents is the expedition of Alexander to Egypt. Winkelman considered it as Menelaus and Helen in Egypt. Count Caylus also published an engraving of it in the same colours as the original. This mosaic, remarkable in particular for the light which it throws on the natural and local history of Egypt, is at present at the seat of the Barberini family, built on the mountain where formerly stood the temple of Fortune, and at the bottom of which is Palæstrina. It is commonly known under the name of the *mosaic of Palæstrina.*—3d, In the pavement of the same temple there was also found another mosaic, of less size, but of workmanship much more elegant than the former: it is at present in the Barberini palace at Rome. It represents the rape of Europa. The upper part exhibits the sea-shore, on which are observed the companions of that princess, and Agenor her father. The same subject is represented on a mosaic engraved by the care of the prelate Casali.—4th, In the villa Albani there is a beautiful mosaic, which was found in the territory of Urbino, and which represents a school of philosophers.—5th, A mosaic representing the history of Hesione, the daughter of Priam, exposed on a rock to a monster, and delivered by Hercules, who gave her in marriage to his friend Telamon, was discovered about the year 1762. According to Winkelman, the workmanship has as great beauty and delicacy as that

that of the pigeons of Furietti.—6th, A mosaic, two palms in height, was found in a villa near Pompeii (perhaps that of the emperor Claudius), in the month of April 1763. It represents three females with comic masks, who play on different instruments: near them is a child, who plays on a flute. Winkelman says that the workmanship of this piece is so delicate that a magnifying glass is necessary to distinguish it. The name of the artist, Dioscorides of Samos, is inscribed on it in Greek letters.—7th, Another mosaic of the same artist, and of workmanship equally delicate, was dug up in the presence of Winkelman in the month of February 1764. It also represents three females with comic masks, and a child wrapped up in a mantle which has no mask.—8th, A mosaic pavement twenty-seven palms in length and twenty-five in breadth was discovered at Præneste in 1766. The design of it was sent to Rome at the time when Winkelman was employed in explaining that of Sylla found at Præneste. The subject of it is not known, nor do we know whether it has been engraved and explained, or to what place it was carried. —9th, An antique mosaic dug up at Rome in 1769; another with flowers, from the villa Hadriani; and a modern mosaic, representing St. Peter and the Virgin, are to be seen at Manheim.—10th, Bartoli's work on the tombs of the antient Romans and Etruscans, reprinted in the twelfth volume of the *Thesaurus Antiquitatum Græcarum* of Gronovius, contains several engravings of antient pavements with mosaics, *viz.* figs. 14, 17, and 18, of the tombs of the villa Corsini; fig. 110 exhibits a beautiful mosaic representing Ganymede feeding the eagle of Jupiter: it was taken from the catacombs of St. Sebastian. The first volume of the *Lucernæ Sepulchrales* of Bartoli and Bellori contains also an antique pavement in mosaic from the tombs of the villa Corsini. It represents, amidst several other figures and ornaments, four naked mimic dancers of that kind who preceded the funerals of distinguished personages among the antients.—11th, Three pavements in mosaic, one of which represents a comic scene surrounded by theatrical masks, flowers, birds, helmets, &c.; the second, Theseus and the Minotaur; and the third, the combat of Entellus and Dares, were discovered, in 1790, without the walls

walls of Aix, in the place occupied by the antient city in the time of the Romans. These mosaics, the destruction of which Saint-Vincens could not prevent, were engraved by the care of his son, and published in the Biographical Notice which the latter gave of his learned father. He could procure only some interesting fragments of them, which he affixed on the walls of his cabinet. Several other mosaics were found at Aix, which have been engraved in the history of that city by Menard. One of them represents a female with a dog and a flambeau: the female has a great resemblance to the goddess Nehalennia of the Gauls. Some pavements which exhibit nothing but compartments were dug up also at Auxerre.

During the searches which the prelate Cazali caused to be made at Rome, there was found a very beautiful mosaic pavement, which contained a representation of the rape of Europa: it was removed to his house to ornament the floor of his apartment, and he likewise had it engraved.

The pavements in the Pio-Clementine musæum are ornamented with several beautiful mosaics. In the vestibule, at the top of the stair-case, there is one, found at Rusinella, near the antient Tusculum, which represents a bust of Pallas in the middle of an elegant grotesque. Another, dug up at Otricoli, ornaments the grand rotundo: it is divided into several zones intermixed with meanders, large compartments containing tritons, nereids, and combats of centaurs, who have in the middle of them a buckler covered with scales, and on which is seen the Gorgon. This large mosaic is surrounded by a border of other mosaics white and black, among which is distinguished the adventures of Ulysses and the Syrens. In an octagon hall close to this rotundo there is seen also a beautiful grotesque of mosaic with a Medusa in the middle, found in one of the vaults of the palace Caetani on the Esquiline hill. Several other mosaics, representing animals and articles of provision, are observed also in other halls.

In the musæum of the Augustines there is a singular mosaic, executed in the sixth century. It is the tomb of Fredegonda, composed of a great number of small stones broken and pounded in a mortar, like those coloured grains with which

which confections are besprinkled. The whole is inclosed in a kind of filigrane of copper, forming a rude design. Dufourny possesses a work of the Lower Empire executed with cubes of enamelled copper.

The Italians at present often employ antique mosaics to ornament the floors of their apartments; and they make use of a very ingenious process, before they remove the mosaic, for fixing with cement the small cubes which compose it; also for detaching it from the place which it occupies, and for depositing it in a new one. They cut it into portions, fix them on large sheets of paper called *perpetuo,* surrounded with iron, which they number, and afterwards, when they wish to make use of them, they place the pieces on the floor according to the numbers; and these portions, when joined, form a whole as smooth as it was before the mosaic was displaced.

The principal works which treat of the theory and practice of mosaic are the following:—J. Ciampini, *On the Mosaics of Temples and other Buildings:* Rom. 1690; fol. 2 vols. Besides the mosaics the engravings of this work represent also the temples constructed till the time of Constantine the Great.—J. Alex. Furietti, *On Mosaics:* Rom. 1752; 4to. with plates. An extract from these two Latin works has been published in French under the title, *Essai sur la Peinture en Mosaïque,* par M. De Vielle: Buonarotti has also spoken of them in his Observations on the antient Glass: Florence 1716: 4to. A dissertation on this subject, by G. Piacenza, may be found in the first volume of his edition of *Notizie dei Professori del Disegno da Cimabue:* Tor. 1768; 4to. Fougeroux de Banderoix gives a *Traité sur la Fabrique des Mosaïques* at the end of his *Recherches sur les Ruines d'Herculaneum:* Paris 1770; 8vo. Count Caylus speaks of them in his *Essai sur la Maniere de Peindre en Marbre,* in the Memoirs of the Academy of Inscriptions, Vol. XXIX. In the last place, M. Gurlitt has given a particular dissertation on mosaic.

The works which contain descriptions and explanations of the most curious antique mosaics are: *Opus Musivum erutum ex Ruderibus Villæ Hadriani:* Flor. 1779. The designs are by C. Savorelli, and the engravings by Capellani. This mosaic represents a hunting party. *Observations sur la Mosaïque des Anciens, à l'Occasion de quelques Tableaux en Mosaïque qui se trouvent à la Galerie des Peintres de l'Electeur Palatin,* par M. l'Abbé Hæfflin, in the *Comment. Histor. Academiæ Theodoro-Palatinæ,* Vol. V. No. 3, p. 89: Manheim 1783; 4to. M. Hæfflin compares mosaic in glass and in stone with the paintings executed by means of the feathers of birds by the Americans: *Explication de la Mosaïque de Palæstrine*; par M. l'Abbé Barthelemy: Paris 1760; 4to. And in the Memoirs of the Academy of Inscriptions, Vol. XXX. Kircher in his *Latium,* and Montfaucon in the fourth volume of his *Supplement de l'Antiquité Expliquée,* had before attempted to give an explanation of this mosaic: *Osservationi di Ennio-Quirino Visconti, su due Musaïchi antichi istoriati:* Parm. 1788; 4to. These two mosaics, which, according to Visconti, relate to pyromancy, were found, in 1788, in the Campagna di Roma. They are now in the collection of the chevalier Azzara; *Description de la Mosaïque trouvée à Seville, et publiée par Ordre du Roi d'Espagne.* Alexander Laborde is about to publish a description of nine mosaics found in Spain.

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## XXXVII. *On the Improvement of Time-Keepers. By* DAVID RITTENHOUSE, *LL.D. President of the American Philosophical Society**.

THE invention and construction of time-keepers may be reckoned among the most successful exertions of human genius. Pendulum clocks especially have been made to measure time with astonishing accuracy; and if there are still some causes of inequality in their motions, the united efforts of mechanism, philosophy, and mathematics, will probably in time remove them.

The last and least of those causes, which perhaps may be worthy of notice when all others of more importance are removed, is that rising from unequal density of the air, which by varying the actual weight of the pendulum will accelerate

* From the *Transactions of the American Philosophical Society.*

or

or retard its motion. The effects arising from this cause will indeed be found very small; for, if we suppose the greatest range of the barometer to be three inches, which indicates a change of density in the air of above one-tenth of the whole; and supposing lead, of which pendulums are generally made, to be 8,800 times heavier than air, the variations of the actual weight of a pendulum may be 1-88000th part of its whole weight, and consequently the change in its rate of going 1-176000th part. And, as there are 86,400 seconds in a day, the clock may vary in its rate of going, from this cause, about half a second in 24 hours. Mentioning the barometer, seems naturally to point out a remedy for this cause of irregularity by means of that instrument. But my design is at present to describe a very different and extremely simple method, which, though only a matter of curiosity at present, may at some future time, perhaps, be found useful; especially as the variation above mentioned is governed solely by the actual density of the surrounding air, and the barometer can only give the weight of an entire column, which does not strictly correspond with the density of its base; whereas the method I propose depends on the real density of the air surrounding the pendulum, and nothing else.

Let AB (Plate VII. fig. 1.) be a pendulum vibrating on the point A, and removed from the perpendicular line DE. Let the inflexible rod be continued from BA to C, and let a body C, of equal dimensions with the pendulum B, but hollow and light as possible, be fixed on the rod, making AC equal to AB. Now it is evident that B will be pressed upwards by a force equal to the weight of its bulk in air, and its descent retarded. But the body C will be equally pressed upwards, and consequently the motion of the pendulum towards the perpendicular will be as much accelerated. These two forces, therefore, will destroy each other, and the pendulum will perform its vibrations in equal times, whether the air be light or heavy, dense or rare.

I have, for greater perspicuity, described the most simple case, but perhaps not the most eligible; for if we can enlarge the vessel or body C in any proportion, the distance of its centre from A may be diminished at the same rate.

 However

However plausible the above may appear in theory, no doubt difficulties will occur when we attempt to reduce it into practice. But I am persuaded they will not be found insuperable.

The only experiment I have hitherto made on this subject has been merely to show that a pendulum can be made in this manner which shall vibrate quicker in a dense medium than in one more rare, contrary to what takes place with common pendulums.

I made a compound pendulum, on the principles above mentioned, of about one foot in its whole length. This pendulum, on many trials, made in the air 57 vibrations in a minute. On immersing the whole in water it made 59 vibrations in the same time, showing evidently that its motion was quicker in so dense a medium as water than in the air. When the lower bob or pendulum only was plunged in water, it made no more than 44 vibrations in a minute; the remaining 15 being solely the effect of the pressure of the water against the upper vessel C.

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## XXXVIII. *Description of a new invented Steam-Engine, intended to give Motion to Water Wheels in Places where there is no Fall, and but a very small Stream or Spring. By* JOHN NANCARROW*.

A, (Plate VII. fig. 2.) the receiver, which may be made either of wood or iron.

B, B, B, B, B, wooden or cast-iron pipes, for conveying the water to the receiver, and thence to the penstock.

C, the penstock or cistern.

D, the water-wheel.

E, the boiler, which may be either iron or copper.

F, the hot-well for supplying the boiler with water.

G,G, two cisterns under the level of the water, in which the small bores B, B, and the condenser are contained.

* From the *Transactions of the American Philosophical Society.*

HHH,

HHH, the surface of the water with which the steam-engine and the water-wheel are supplied.

*a, a,* the steam-pipe, through which the steam is conveyed from the boiler to the receiver.

*b,* the feeding-pipe for supplying the boiler with hot water.

*c, c, c, c, c,* the condensing apparatus.

*d, d,* the pipe which conveys the hot water from the condenser to the hot well.

*e, e, i,* valves for admitting and excluding the water.

*ff,* the injection-pipe, and *g* the injection-cock.

*h,* the condenser.

It does not appear necessary to say any thing here on the manner in which this machine performs its operations without manual assistance, as the method of opening the cocks, by which the steam is admitted into the receiver and condensed, has been already well described by several writers. But it will be necessary to remark that the receiver, penstock, and all the pipes, must be previously filled before any water can be delivered on the wheel; and when the steam in the boiler has acquired a sufficient strength, the valve at *i* is opened, and the steam immediately rushes from the boiler at E into the receiver A; the water descends through the tubes A and B, and ascends through the valve *k,* and the other pipe or tube B, into the penstock C. This part of the operation being performed, and the valve *i* shut, that at *l* is suddenly opened, through which the steam rushes down the condensing-pipe *c,* and in its passage meets with a jet of cold water from the injection-cock *g,* by which it is condensed. A vacuum being made by this means in the receiver, the water is driven up to fill it a second time through the valves *e, e,* by the pressure of the external air, when the steam-valve at *i* is again opened, and the operation repeated for any length of time the machine is required to work.

There are many advantages which a steam-engine on this construction possesses beyond any thing of the kind hitherto invented; a few of which I shall beg leave to enumerate.

1. It is subject to little or no friction.

2. It may be erected at a small expense when compared with any other sort of steam-engine.

3. It has every advantage which may be attributed to Boulton and Watt's engines, by condensing out of the receiver, either in the penstock or at the level of the water.

4. Another very great advantage is, that the water in the upper part of the pipe adjoining the receiver acquires a heat, by its being in frequent contact with the steam, very nearly equal to that of boiling water: hence the receiver is always kept uniformly hot, as in the case of Boulton and Watt's engines.

5. A very small stream of water is sufficient to supply this engine, (even where there is no fall,) for all the water raised by it is returned into the reservoir HHH.

From the foregoing reasons it manifestly appears, that no kind of steam-engine is so well adapted to give rotatory motion to machinery of every kind as this. Its form is simple, and the materials of which it is composed are cheap; the power is more than equal to any other machine of the kind, because there is no deduction to be made for friction, except on account of turning the cocks, which is but trifling.

Its great utility is therefore evident in supplying water for every kind of work performed by a water-wheel, such as grist-mills, saw-mills, blast-furnaces, forges, &c.

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## XXXIX. *History of the Art of Dyeing, from the earliest Ages. By* J. N. Bischoff.

[Concluded from Page 217.]

If the history of dyeing in the former period appears imperfect and deficient, it will be found still more so in the present one, which contains an account of the state of it in the west after the fifth century. And, indeed, it needs excite no wonder if great silence prevails respecting an art at that time so little valued, as we are left in much uncertainty in regard to many other things of great importance. This much, however, we know, that during the general banishment of the sciences, arts, and manufactures from the west, in consequence of the incursions incessantly made by multitudes of barbarians and warlike nations, that of dyeing was among

among the number. It cannot, however, be denied that there occur traces of this art being practised in some of the Italian monasteries and other places. But the articles dyed were of little importance, being chiefly brown or black linen, or skins, so that the art in this state scarcely deserves the name of dyeing.

Of this art Muratori gives only one instance in the eighth century from an old manuscript preserved in a monastery*, which, on account of the barbarous Latin in which it is written, and the illegible passages in it, is scarcely intelligible. This, however, is sufficient to give us an idea of the state of dyeing in the west at that period; but if more should be thought necessary, I have no doubt that there are documents in old monasteries to satisfy the curiosity of those who wish for further information on the subject.

It is certain, indeed, that the art of giving cloth and other articles a beautiful dye, had disappeared from the west in the fifth century, and was to be found only in the east†. But even there little attention was paid to improvement and new discoveries, as dyers were satisfied with those colours which had been long usual, and which, in a great measure, have been already described.

The Greeks and Saracens were for a long time the exclusive possessors of this art, and furnished the west with dyed stuffs, and particularly purple, which, according to the account of the female Greek writer mentioned in the former part of this paper, was prepared there of a beautiful colour in the 11th century. The public taste, however, was at length changed, and people began to set as great value on the scarlet then dyed as upon purple, and at length to prefer it; and on this account, in the 12th century, the art of dyeing purple in the east was entirely forgotten‡.

* Muratori Dissertat. de Artibus Italicor. post Inclinationem Romani Imperii; in his Antiquitat. Italic. vol. ii. diss. 24. p. 367.

† It is not improbable, therefore, that Attila brought with him that purple cloth with which his throne, according to an old poet, was hung round during a great festival. See the *Deutsches Museum* for Jan. 1780, p. 69.

‡ Muratori Dissertat. de Textrina et Vestibus Sæculorum Rudium; in vol. ii. Antiquitat. Ital. diss. 25. p. 415.

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Though, in consequence of the crusades in the 11th and following centuries, this art began to be revived in the west, as the Christian princes who went on these expeditions brought back with them a great many Greek artists, dyeing had been so little improved, that, according to the testimony of an old English poet, Gualfred de Winesauf, who wrote a satire about the year 1202, the Romans at that period obtained their scarlet from Greece *. Soon after, however, the Italians, and particularly the Venetians, made considerable progress in this art: for as the crusaders were conveyed to the Holy Land and brought back from it chiefly in Italian ships, the Italians had the best opportunities either of learning the art of dyeing beautiful colours themselves, or of carrying back expert dyers, whom they must have found very necessary to their manufactures, which were then beginning to increase †. About this period, therefore, we find here and there traces of new dye-materials, or, at least, materials not before mentioned. Thus, a charter of the year 1194, which is a contract between the inhabitants of Bologna and those of Ferrara respecting certain duties, speaks of Brasil grains *(grana de Brasile)* and of indigo, as articles which were obliged to pay duty at Bologna ‡.

In regard to the indigo here mentioned, I can hardly believe that we are to understand by it our dye-stuff of the same name; as a more modern writer, Plictho, whom I shall mention hereafter, was unacquainted with our indigo. It is much more probable that what is here meant is the substance which occurs in Pliny under the name of *indicum*, and which was merely a paint §. In the like manner, a paint was known in Germany called *endich* before real indigo was known; which, as we are told by Crolach in his description

* Muratori ut supra.

† So early as the year 1338 there were in Florence 200 cloth manufactories, which manufactured annually from 70 to 80,000 pieces of cloth, valued at 1,200,000 florins.—See *Della Decima*, tom. ii. p. 3. sez. 4. c. 9.

‡ Muratori Dissert. de Mercatibus et Mercatura Sæculorum Rudium, tom. ii. Antiquitat. diss .30. p. 898.

§ Plin. lib. xxxv. cap. 6. He describes this colour as a scum which adhered to certain reeds.

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of woad, taken from an old author, was made of what the dyers at present call the flower of the woad.

But the Brasilian grains and Brasilian wood are mentioned in more old charters, as, for example, of the years 1198 and 1306, under the name of *braxilis*. This wood, therefore, may have not taken its name from the country called Brasil; but the latter rather got its name from the wood, which was found there in abundance, and in the language of the country was called *ibirapitanga*. In my opinion the name *brasilis* comes from *bragia*, in French *braise*, a burning coal, which it may have obtained both from its colour and its having the property of communicating it to others. But, as I shall have an opportunity hereafter of enlarging further on this dye-stuff, I shall proceed to another discovery of that period, made by a Florentine, *viz.* that of dyeing by orchilla-weed.

A Florentine merchant, who about the year 1300 traded in the Levant, happening to make water on a rock, observed that the green colour of the moss which grew on it, and on which the urine accidentally fell, was changed to a beautiful blueish colour. Reflecting a little further on this circumstance, he found after several experiments, that when mixed with urine and other things it communicated to cloth a columbine colour. This process he long kept as a secret, and acquired by it a great deal of money. The invention at that period was so profitable to the Florentines, and excited so much wonder, that the family of the inventor, which still exists in Italy, were called Rucellai, from the name of the moss, which in Spanish is distinguished by the appellation of *orciglia*, and the dye made from it is called orchilla*.

After this period the manufactures in Italy increased so that the attention of the different governments was particularly directed to the art of dyeing. In the year 1429 there were published at Venice some regulations respecting dyeing (*Mariegola dell' Arte dei Tintori*), in which certain precepts were given for dyeing, and according to which dyers were to exercise their art †. These regulations were renewed in the year 1510, with a great many improvements. One John

* Domenico Manni Commentar. de Florentinorum Inventis, c. 20.

† Zanon Lettere dell' Agricultura, &c. tom. iii. p. 2. lett. 6.

Ventura Rosetti, however, finding these precepts too imperfect, made a tour, at considerable expense, through Italy and other countries to procure information respecting the art of dyeing, and on his return wrote, under the assumed name of Plictho, a book on it; the first, perhaps, that ever appeared on this subject, and which undoubtedly laid the first foundation for the improvement in this art which afterwards took place *.

The title of this work, exceedingly scarce even in Italy, an original edition of which is preserved in the royal library at Göttingen, is as follows:—Plictho's Art of Dyeing; which teaches how to give to Cloth, Linen, Cotton, and Silk, real and beautiful as well as false and common Dyes. *Venice* 1548. 4to.† The whole work is divided into three sections; the first of which treats on the dyeing of wool, linen, cotton, chintz, &c. the second on the dyeing of silk, and the third on the dyeing of skins.

However difficult it may have been at that time to write upon this art, Plictho, in the preface to his book, where he speaks of the period in which he lived with a candour peculiar to himself, says: "I will therefore, dear reader, no longer keep back these three works. I have exerted myself with all my powers by day and by night for months and years, with danger and loss, at the expense of much hard labour, and as far as my poor circumstances would permit, to improve this important art, for sixteen years past, and with God's help to bring it to a proper state."—This author was not acquainted either with indigo or cochineal; but he speaks of brasil wood, which he calls *verzino*, a name still given to it

* Beckmann's Technology, p. 60.

† The Italian title is Plictho de larthe de Tentori, che insegna Tenger Panni, Telle, Banbasi et Sede, si per larthe magiore come per la commune. *Vinegia* 1548. 4to. The real name of the author, as I have already observed, was John Ventura Rosetti; he was overseer of the arsenal of Venice, as he gives us to understand himself in the end of his book. This work has been translated into French under the following title: Suite du Teinturier parfait, ou l'Art de Teindre les Laines, Soyes, Fils, Peaux, Poils, Plumes, &c. comme il se pratique à Venize, Genes, Florence, et dans tout le Levant; et la Maniere de passer en Chamois toute Sorte de Peaux, traduite de l'Italien. *Paris* 1716.

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in Italy, and from which the word *brasilis*, as appears, has been derived. Though Hellot and others despise this work as a wretched collection of recipes, we cannot deny the author the merit of having first opened the way to improve the art of dyeing; of having brought it into high reputation; and in particular, of having excited towards it the attention of foreign nations.

For about two hundred years before, the Italians, and particularly the Venetians, had a monopoly of dyeing, and procured large sums by it from neighbouring nations, who made no exertions to practise the art themselves; for statesmen and men of letters did not think it worth their while to give themselves any trouble about it, and from dyers no change whatever was to be expected. But Plictho was the first who exhibited this art in its full lustre, and excited the French, English, and Germans, to apply in earnest, in their different countries, to the improving so useful and extensive a branch of manufacture.

In France some progress towards this object had been already made. One Giles Gobelin, who had learned from a German the art of dyeing scarlet, endeavoured to establish it in that country, and for this purpose erected a dye-house, in the suburbs of Paris, on a small stream called the *Bievre*, the water of which was found peculiarly favourable to that colour. This undertaking was at first considered to be a work of so much difficulty that no one believed he would be able to complete it, and for that reason this dye-house was called *La Folie Gobelin*, that is, Gobelin's Folly*.

Gobelin, however, continued his business, and scarlet dyed after his manner is still called Gobelin's scarlet, and a building in which tapestry is now made is still distinguished by his name†. But dyeing in general continued in a very imperfect state

* See *Histoire de l'Academie Royale des Sciences de Berlin* for 1767, p. 67.

† People at that time were so ignorant in matters of this kind that they could not believe that Gobelin performed what he did without supernatural assistance. They invented, therefore, the following story:—Gobelin is said to have entered into a compact with the devil, who was to teach him the art of dyeing scarlet; and, having learned it, he gained by it a great deal of money. When the term of the compact, however, was nearly

state till Colbert, the great minister of Louis XIV. in the year 1669, undertook to pay attention to its improvement. With this view he examined the establishment and defects of the French dyeing, and a M. d'Albo, at his desire, composed a set of regulations respecting dyeing, which were printed and published at Paris in the years 1669 and 1672*.

The introduction to this book contains a proof of Colbert's mode of thinking in regard to this art:—"If the silk, woollen, and linen manufactories," says he, "are those which contribute most to the support and advancement of trade and commerce, dyeing, which supplies that variety of colours by which the most beautiful things in nature are imitated and represented, may be considered as the soul of it, without which the body would be animated only by feeble life. Wool and silk in their natural colours, formerly raw articles of little value, now find sale in the country, when they have received from dyeing those attractions which render them valuable and agreeable to the most savage nations."

The treatise itself is divided into twelve chapters: the first treats on the five principal colours, and the preparation of the articles before they are dyed; the second, of the application of the dye-stuffs; the third, of the different shades of the above

nearly terminated, as Gobelin was passing through the court-yard with a light in his hand, the devil came to fetch him away. Gobelin begged for a respite, but the evil spirit would not grant it. Gobelin at last requested that the devil would wait till the bit of candle in his hand was burnt out. This being granted, Gobelin immediately threw it into a well and pushed the devil in after it. The devil thus outwitted was exceedingly angry; but Gobelin had time to get a guard of ecclesiastics, who secured him from similar attacks in future.—See *Zanon* as above, sixth book, third letter.

* The title is: *Instruction générale pour la Teinture des Laines et Manufactures de Laine de toutes Couleurs, et pour la Culture des Drogues ou Ingrédiens qu'on y employe:* à Paris 1672. 12mo. This work was reprinted in the last century under the following title: *Le Teinturier parfait: ou Instruction nouvelle et générale pour la Teinture des Laines et Manufacture de Laine de toutes Couleurs, et pour la Culture des Drogues ou Ingrédiens qu'on y employe:* à Leyde, chez Theod. Haack, 1708. 8vo. The last edition appeared in 1726 in two parts. There is also a German edition by Paul James Marperger, with the title *Ars Tinctoria fundamentalis.* Respecting this book see *Memoires concernant les Arts et les Sciences* for the year 1673; and the *Leipz. Sammlungen,* vol. iii. for 1746, p. 1013.

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colours; the fourth, of compound colours; the fifth, of the division of colours into fine colours (*teinturiers en bon teint*) and common colours (*teinturiers en petit teint* *); the sixth, of the dyers' marks, with which they mark the articles they dye in both the above ways; the seventh contains a catalogue of the dye-stuffs permitted to be used for dyeing the fine and common colours; the eighth gives an account of the reasons why certain kinds of dye-stuffs are prohibited; the ninth treats entirely on dyeing black; the tenth, of the ground and bath proper for each colour; the eleventh treats on the dyeing of linen and hats; and the twelfth recommends the use and cultivation of indigenous dye-stuffs, a list of which is given.

That these regulations might be properly observed, certain inspectors and commissioners were not only appointed to visit the dye-houses and repositories of the merchants, but orders were afterwards given to a member of the Academy of Sciences to make experiments for improving and beautifying different dyes, and to lay the result of his discoveries before the academy, which were afterwards to be published for the practical use of dyers.

The great advantage of this establishment may be easily conceived from the preference given to the French dyes; and the works which Du Fay, Hellot, and others, have written on this subject, and with which every dyer ought to be acquainted.

About this time the dye-stuffs brought to Europe from the newly discovered countries, but especially indigo and cochineal, began to be employed with great advantage. The Netherlanders, in particular, endeavoured, by means of these new dye-stuffs, to discover more durable and livelier colours; for though they had begun, almost at the same time as the Italians, to apply to the art of dyeing with great zeal, and to take advantage of the troubles in the East, they had never been so fortunate, notwithsanding all their exertions, as to make any great progress in it.

* This division was made in the earliest periods in Italy as well as in France, as proved by a French ordinance of Nov. 17, 1383; but it had not been so strictly observed till Colbert found it necessary to define it more accurately.

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At last a Flemish painter named Peter Kloeck, who, during his long travels in various parts of the East, had learned the art of giving the most beautiful colours to silk and woollen stuffs, as well as that of dyeing scarlet, which he acquired from the German inventor whom I shall mention hereafter, returned to his own country*, excited as much attention by his method as Gobelin did at Paris, soon brought dyeing into repute, and continued to practise his art till 1550, when he died†.

After that epoch this art was exercised by the Flemings with so much zeal, that the Netherlands afterwards supplied not only France, but even England and Germany, with experienced dyers.

Dyeing seems to have been practised also in England at a very early period, for in the 14th century Edward III. brought a great many dyers from Flanders‡. Under Edward IV. dyers were so numerous in London, that in the year 1472 they were established into a particular company, which at present forms one of the ninety-two incorporated companies, and holds the thirteenth rank: this company has its own arms, and its hall on Dowgate-hill§.

After the discovery of America the new dye-stuffs began to be used also in England; but here people were at first so mistrustful of them, that under queen Elizabeth dyeing with indigo was not only limited, but the use of logwood was entirely prohibited, and it was burnt wherever it was found||. This prohibition was afterwards repeated, but it was annulled under Charles II. in 1661.¶

* Beckmann's Technology, p. 64.

† Mem. de l'Acad. de Berlin, 1767, p. 92.

‡ Rymer's *Acta publica*, tom ii. p. iii. p. 68.

§ Noorthouck's New History of London, vol. ii. p. 601.

|| The Statutes at large. Statute 23 Eliz. c. 9; an act for abolishing of certain deceitful stuff used in dyeing of cloth, &c.

¶ Statutes of Charles II. 13. c. 11. Frauds and abuses in his majesty's customs prevented and regulated. Under this head the following passage occurs:—"As it has now been found that our dyers, by diligence and dexterity, have made such progress as to be able to dye with logwood as good and durable colours as with other kinds of wood, the use of this wood is in future permitted."

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But notwithstanding the attention hitherto paid to dyeing by government, it still remained in a languishing state till the year 1643, when a German named Kepfler first brought to England his new-invented method of dyeing scarlet; and because he established a dye-house at the village of Bow, the scarlet he dyed was called the *Bow dye**. At length a Fleming named Brauer, who in 1667 went to England with his whole family, brought the dyeing of woollen there, in general, to that degree of perfection at which it has been since maintained by the English †. Men of letters in England now began to turn their attention to this art, and we find a treatise on dyeing published in 1667 ‡, which was soon followed by others of the same kind.

As a distinction had always been made in Italy, France, and the Netherlands, between fine and common dyers, the case appears to have been the same in England from the earliest periods; so that blue, red, and yellow, belonged exclusively to the fine dyers; but both the fine and common dyers were allowed to dye brown, fawn-colour, and black §.

Since the art of dyeing, as we have already seen, could not be revived in Italy, France and the Netherlands, from its long state of depression to which it had been subjected in the fifth century, it will not appear surprising that the Germans, who during the middle ages paid very little attention to manufactures, should begin to apply later than other nations to this art, which is always an attendant of manufactures. All the beautiful, lively, and high colours, which are mentioned by the German writers of that period, were procured from the Italians, as these had procured them from the Greeks.

It is probable that the Germans had dyers of their own for black and brown colours, as the former was their gala colour or colour of honour, and the latter the common colour of the monks and other people, both of which required no foreign dye-

* Anderson's History of Commerce, vol. ii. p. 77.

‡ Anderson's History of Commerce, vol. ii. p. 132.

‡ William Petty's Apparatus to the History of the Common Practices of Dyeing, in Sprat's History of the Royal Society of London, p. 284.

§ Chambers's Dictionary of Arts, under the head Dyeing.

dye-stuffs or expensive preparation. But this scarcely deserved the name of dyeing, and extended at most to linen or coarse woollen stuffs, and even to these the dyers could not communicate fast and durable colours.

As the number of those who prepared these colours afterwards increased, the first dyers were under the necessity of forming themselves into a company to secure themselves and their occupation from the encroachment of foreigners; and this was the origin of that company known in Germany at present under the name of *black dyers;* but whether this society was formed under Henry I. in the year 925, as the chancellor Von Ludewig asserts*, cannot be with certainty determined. With the above two colours the Germans were long satisfied, till at length, in the 12th century, a great many artists and manufacturers took shelter in Germany in consequence of Milan being over-run by the emperor Frederic I.; and by the crusades the Germans in the East became more and more acquainted with the woollen manufactories, which they afterwards brought back with them into their own country†.

These circumstances, and the encouragement given to the German navigation and trade with foreign nations‡ by the Rhinish and Hanseatic league in the 13th century, encouraged the Germans not only to apply with more ardour to their home manufactures, but rendered it necessary for them to obtain better dyers and dye-stuffs, that their manufactures might find a good sale in foreign markets. They endeavoured, therefore, to procure from Italy and the Netherlands, where the art of dyeing, as is well known, had been much cultivated, expert workmen§, who, from the woad which they chiefly employed for dyeing blue and green colours, were called *woad dyers* and also *cloth dyers*||, because they dyed only

* Ludewig Dissert. de Re Bafiaria Tinct. p. 11.

† See Püttner's *Deutsche Reichsgeschichte,* § 107. III. p. 257.

‡ Ibid. § 118. p. 291.

§ Ludewig *ut supra,* p. 12. Schreber's *Abhand. vom Waidt,* part 5. § 3. Zink's *Manufactur und handwerks Lexicon,* under the word Dyer.

|| The appellation *woad dyer* occurs in a charter of the year 1339. Zink, therefore, is wrong when he says that woad was not used till a late period, and

only good cloths. They were called likewise *Rhenish dyers*, either because the Rhenish league encouraged cloths of beautiful colours, or because a great many dyers from Rhineland had settled in other provinces of Germany.

The above league, however, endeavoured to encourage dyeing in Germany, not only by promoting trade and procuring expert dyers, but also by various laws and regulations. Thus we find, besides others, an ordinance of the Hanse towns, written at Lubec, in Latin, in the year 1418, the sixth section of which contains the following passage:—"No merchant shall purchase undyed cloth in any town and dye it in another; but the cloth shall be dyed in the place where it is bought, under the penalty of forfeiting the cloth and the dye-stuffs*."

After this period we find two kinds of dyers in Germany, *viz.* the before-mentioned *cloth, woad,* or *Rhenish dyers*, and the old *black* or *ordinary dyers*. The former endeavoured chiefly to improve their art by new inventions, as was the case in the 16th century, when a fine dyer, whom some call Küster, others Küffler, some Kepfler, and the Dutch Drebel, found out, by means of a solution of tin, the art of dyeing the new scarlet colour†. From this dyer the before-mentioned German painter, Kloeck or Glück, learned the art; and Gobelin having been taught it by the latter, it was soon made known over a great part of Europe. Besides, the Germans now began to establish silk manufactories; and as silk required a particular method of dyeing, there arose a new kind of dyers called *silk-dyers*, of whom mention is made in the laws of the empire in the 16th century‡.

At last dye-stuffs, before unknown, from the newly-discovered countries, or at least such as were rare and expensive,

and that, therefore, the black dyers, by way of ridicule, called the *fine dyers woad dyers*.—See *Grosser Analecta Fastor. Zittauiensium*, p. iv. c. 4. p. 168. § 10. The name *cloth dyer* occurs frequently in the laws of the empire. For example, in those of the year 1577, under the head Purchasing of Woollen Cloth, § 21. also 3.

* Pütter's *Reichsgeschichte*, § 145. iv. not. 10.

† Hellot on Dyeing, p. 276; Beckmann's Technology, p. 64. The antients had a scarlet colour which they dyed with the *coccum* kermes.

‡ See *Reich's Absch. zu Regensburg* for the year 1594.



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being imported into Europe, were much employed by the German, Italian, and French dyers. By these productions they were enabled to prepare dyes much more beautiful and at less expense than they had ever been able by means of the dye-stuffs before known.

As the Germans did not obtain these new dye-stuffs so early, and were not yet acquainted with the art of treating them, the Flemish and French dyers came to Germany in great numbers, and united themselves to the German cloth and woad dyers, under the name of the *art, woad,* and *fine dyers* *.

Thus, in the middle of the 16th century, a Fleming named John Nicolaus Schmidt established a house for fine dyeing at Gera †. But on this occasion the jealousy and envy of the black dyers, who had hitherto been secret enemies to the woad dyers, were displayed in their full force. They not only persecuted with all their might the new strangers, but they endeavoured to make the new dye materials, which the fine dyers particularly used, to appear to the different princes contemptible and pernicious; especially as they were already disagreeable to financiers, because they lessened the consumption of indigenous productions, and especially of woad. The elector of Saxony ‡ and duke Ernest the Pious §, therefore, not only issued severe prohibitions against indigo; but it was made a subject of discussion at the diet, where it was described as a pernicious eating devil and corrosive dye-stuff ||.

The use of these ingredients, however, had become so prevalent, and their superiority to the indigenous was too evident to admit of their being entirely banished. On the other hand the division into fine and common dyers, to which the French and Dutch dyers were already accustomed, was more firmly established; and both kinds distinguished themselves by their greater or less dexterity; by the dye-stuffs they employed;

* Hence arose, no doubt, the connexion which still subsists between the German fine dyers and the French, English, and German dyers, as the black dyers cannot go beyond the boundaries of Germany.

† Ludewig *ut supra*, p. 1.

‡ *Codex Augustæus,* part i. p. 236, 1521, 1547.

§ Gothaische Landeforduung, p. 2.

|| R. Pol. O. zu Frankf. 1577. tit. 21. § 3.

ployed; the instruments they used; their fellowship; and, in the last place, by the objects to which their attention was chiefly directed.

The black and common dyers, particularly in Saxony, learned the art of communicating good dyes to linen or linsey-woolsey, and assumed the title of *black* and *fine dyers*, by which they endeavoured to distinguish themselves from the *common linen dyers*, as they were then called. They were, however, established into one company with the black and fine dyers by an ordinance of the elector of Saxony, dated May 24th 1595, and divided into three principal branches, *viz.* those of Leipzic, Dresden, and Zwickaw*; and this union chancellor Von Ludewig considers, improperly, as the union of the *art dyers* with the *black dyers*†. Such is the state of dyeing at present in Germany, and of the establishment of the dyers.

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## XL. *A Biographical Sketch of Count* Rumford.

Sir Benjamin Thompson, Count of Rumford, a native of America, was born in the town of Rumford, in the province of Massachusets. In the American war he raised a regiment of dragoons, and signalized himself on different occasions in the service of the mother country. In February 1784 he received from His Majesty the honour of knighthood; and in the same year, with his sovereign's permission, engaged in the service of his Serene Highness the Elector of Bavaria.

In that electorate his services were of the most active and useful kind; for, in addition to the duties of his military profession, he devoted himself to the amelioration of the condition of the vagrant poor: a Herculean labour, of which no one can form an adequate idea without perusing the account since published by the Count, and yet managed with so much address as to conciliate the good wishes of even the

* Schreber Beschreibung des Waidts, part 5. § 3.

† Ludewig *ut supra.* This perhaps may have induced Von Justi, in his *Policeywissenschaft,* vol. i. book 5. p. 20. div. 3. § 583. to make the same assertion.

mendicants themselves, and to beget in them habits of industry, cleanliness, and sobriety.

In pursuing the plans of œconomy necessary to give the greatest efficacy to these improvements in Bavaria, he was led to devote his attention to the means of providing the greatest quantity of nutriment with the least possible expense, and at the same time pleasing and palatable. The œconomy of fuel also claimed his attention; and to these laudable motives we think the world is chiefly indebted for the philosophical investigation of those important particulars so ably conducted by count Rumford in his various Essays, and from which, in former volumes, we have laid several interesting abstracts before our readers.

The estimation in which these services rendered to Bavaria were held by the elector may be estimated by the marks of honour conferred by him on the person who rendered them; who was created count of Rumford, knight of the orders of the white eagle and St. Stanislaus; and appointed chamberlain, privy counsellor of state, and lieutenant-general in the service of the duke of Bavaria, colonel of his regiment of artillery, and commander in chief of the general staff of his army. The monument erected at Munich in 1795, in commemoration of his public services, of which our readers will find an account in our fifth volume, pages 205 and 312, will serve to hand down to posterity the remembrance of the gratitude of those who erected it.

To dwell upon the benefits resulting to society from pursuits like those in which the count has been occupied is altogether unnecessary: the public kitchens in almost every town and village in the kingdom are practical commentaries upon them, which speak more to the feeling mind than could the most elaborate eulogium.

Of living characters propriety demands that we should say but little. Before closing, however, this very brief sketch, we must take notice of the zeal manifested by the Count for even the future furtherance of the advantages resulting to mankind by the œconomy of fuel. For this purpose, on the 12th of July 1796, he deposited with the Royal Society one thousand pounds stock in the three per cent. consols, "to the end that the

the interest may be applied once every second year as a premium to the author of the most important discovery or useful improvement which shall be made and published by printing, or in any way made known to the public in any part of Europe during the preceding two years, on heat or on light; the preference always being given to such discoveries as shall, in the opinion of the president and council of the Royal Society, tend most to promote the good of mankind."

The formalities to be observed by the president and council in deciding on the comparative merits of those discoveries which in their opinion might entitle the authors to be considered as competitors for this biennial premium, the Count left to the president and council to determine as in their wisdom and judgement they might judge necessary. But in regard to the form in which this premium is to be conferred, his request was, "that it may always be given in two medals, struck in the same dye, the one of gold and the other of silver, and of such dimensions that both of them together may be just equal to the amount of two years interest of the stock; that is to say, that they may together be of the value of sixty pounds sterling.

"Should it so happen at any time that no new discovery respecting heat or light should be made in any part of Europe within two years from the preceding adjudication, which in the opinion of the president aud council of the Royal Society should deserve this premium, in that case the Count desires "that the premium may not be given; but that the value of it may be reserved, and, being laid out in the purchase of additional stock in the English funds, may be employed to augment the capital of this premium; and that the interest of the same, by which the capital may from time to time be augmented, may regularly be given in money with the two medals, and as an addition to the original premium, at each succeeding adjudication of it." And it is further his "particular request that those additions to the value of the premium, arising from its occasional non-adjudications, may be suffered to increase without limitation."

It is principally to the exertions of this active individual, in which he was ably supported by the worthy president of the

the Royal Society, that the world is indebted for the establishment of the ROYAL BRITISH INSTITUTION, which promises to be of the greatest public benefit.

To conclude: The different productions of count Rumford on scientific subjects, published in the Philosophical Transactions and in separate essays, are so well known to the public that any enumeration of them in this place is unnecessary. His writings are also well known on the continent; indeed many of them have been translated, and from all of them large extracts have been given in different European languages.

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## XLI. *Account of Messrs.* TURNBULL *and* CROOK'S *new Method of Bleaching or Whitening and Cleansing Cotton-Wool, Flax, Hemp, &c. and Goods manufactured from any of these Materials.*

THE inventors of this method have secured the same by patent, and the present account is extracted from their specification.

The goods to be bleached or cleansed are directed to be first washed, and freed from the dirt and foreign matters that may be adhering to them, and from any kind of paste or dressing (as the workmen call it) which may have been used in their manufacture. This is to be performed by mill-washing or any of the usual processes.

When thus cleansed they are put into a lye of vegetable or of mineral fixed alkali, or of the volatile alkali, either mild or made caustic by quicklime, or into a lye of quicklime only, or into a soapy lye, or into a lye composed of all or any of these substances, (with or without the addition of oxygenated muriatic acid,) of a strength fit for the purpose of extracting the coloured or colourless gummy, resinous, or other impurities which may exist naturally in, or which may have been introduced (by accident or design) into the fibre or texture of the materials or goods under process, and which are too intimately united with them to admit of being removed by the first above-described washing or cleansing. The alkaline, soapy, or other lye may be prepared by the method or methods

thods usually followed by bleachers; the present invention not consisting in the kind of alkaline lyes or other liquors employed, or in the way of preparing them, but in the mode of applying such alkaline, soapy, or other lyes, and in the method of obtaining and applying the volatile alkali or ammonia to the same purpose; for when the goods or articles to be bleached are immersed in the alkaline, soapy, or other lye or liquor as before directed, instead of boiling or bucking them in it, as is the practice usually followed, the patentees only steep them, or keep them long enough in the said lye to be thoroughly impregnated with it, which requires a longer or shorter time according to the quantity and texture of the articles or goods. The goods are then drawn out upon a rack over the vessel in which they were impregnated, and suffered to drain, that the superficially adhering lye or liquor may run from them back into the said vessel. After this draining, the goods will still hold a sufficient quantity of the lye or liquor employed to answer the end in view. They are then put into a vessel of sufficient strength and dimensions, which they call the steaming-vat, and which is connected, by means of a pipe, tube, or hose, with a boiler, kettle, or caldron, which they call the steaming-kettle, and which may be of any convenient form and dimensions. The tube above mentioned may pass from any part of the edge or of the side of the steaming-kettle, or even from its cover, which ought to fit steam-tight into any part of the side or bottom of the steaming-vat, the intention and use of it being to convey steam from the foresaid kettle to the foresaid vat, and is furnished with a stop-cock, a valve, or any contrivance that will answer the purpose of shutting and opening at pleasure the communication between the said kettle and vat. The steaming-vat ought, for the convenience of lifting out the goods, to be furnished with a false bottom of some kind in the inside, as of wood or of net-work, for the goods to lie upon; and to this false bottom should be attached ropes, by means of which, and the assistance of a crane and pulley, or any other convenient mechanical power, the goods may be withdrawn from the vat after the operation of steaming the goods. The operation of steaming the goods is performed by opening the communi-

communication between the steaming-kettle and steaming-vat; the former, which contains some water or aqueous solution, being kept at a proper heat by means of a fire put under it, and the latter having previously its cover fitted on steam-tight. The steam is thus, as it were, pent up in the kettle and vat, and made to act with any pressure that may be desired, or that the strength of the vessels may be able to sustain. To secure the safety of the people employed, the apparatus ought always to be furnished with a safety-valve, attached to any part of the steaming-kettle or of the steaming-vat, or of the tube of communication, that, when the elastic force of the inclosed steam reaches a determined point, the valve may open of itself, and allow a portion of it to escape. By this process the goods can be heated considerably above the boiling point; a circumstance that adds so much to the dissolving power of the alkaline or soapy or other lye, that the quantity left in the goods after draining, as before described, is found sufficient to dissolve and discharge by one steaming as much of the resinous, gummy, or other impurities from the goods under process, as could have been discharged by a long boiling of the goods in the lye itself, as is the usual practice; and by this means a great saving is made in the alkalies and other ingredients employed for whitening the goods. For in the common method the colouring matter, as discharged from the fibre or texture of the goods, is diffused throughout the whole lye; which soon renders it so foul, that it is obliged to be changed long before it has become saturated with the substances or matters on which it exercises its power. But by this method there is no more lye employed for one steaming than what is sufficient merely to impregnate the goods thoroughly; and the alkali, thus deposited in the texture or fibre of the goods under process, is more or less disengaged from the said texture or fibre by the action of the steam, and is found at the bottom of the steaming-vat, of a dark colour, occasioned by the matters it has dissolved and carried down with it. The steaming-vat may be very commodiously freed from this deposit by a common stopcock, or even a plug, at or near its bottom, to be opened as often as may be necessary.

The same end is also effected by using only a deep boiler with

with a steam-tight cover, and suspending the goods previously impregnated with the alkaline or other lye, as before directed, on frame and net work over boiling water in the said boiler, and employing oxygenated muriatic acid, acidulated waters, mill washing, or exposure to the sun and air when these may be necessary. Particular care must be taken to keep a supply of water or some aqueous solution in the lower part of the boiler below the frame or net work on which the goods lie, as otherwise they may be singed or actually burnt, and a loss be consequently incurred. But putting them in steaming-vats is preferable to putting them in a boiler in the manner just described; and that on several accounts, but especially because by means of one steaming-kettle steam can be thrown into as many vats as can be conveniently ranged round it; which is a mean of making a considerable saving in the article of fuel.

One steaming generally requires from four to eight hours; but the length of time will vary according to the kind or quality of the goods to be whitened, and the strength of the lye that has been employed for impregnating them. After the steam has been continued a sufficient length of time, the cover of the steaming-vat is taken off, the communication with the steaming-kettle is cut off by means of the foresaid cock or valve provided for that purpose, and the goods are lifted out by means of a crane or pulley, or other fit mechanical power, as before mentioned. They are then well washed by milling, or by any of the processes followed by bleachers: after this they are again impregnated with lye, steamed, and then washed; and these manipulations are repeated in the manner that has already been described, till the goods are brought to the required degree of whiteness and purity. The usual operation of steeping in acidulated waters, and exposure to the sun and air, or to the action of the oxygenated muriatic acid, in such stages of the process as the bleacher may think proper, may be employed with advantage in this method as well as in the common and usual method of bleaching. Every bleacher's own experience must point out to him, that when acidulated waters, exposure to the sun and air, or the oxygenated muriatic acid, are to be employed after any steaming, the goods should first be washed.

When silk, sheep's wool, or goods containing sheep's wool, or animal hair or fur of any kind, are wished to be cleaned, scoured or whitened by the above described method, the lye employed ought to be much weaker than in the case of cotton, flax, or hemp, or of goods manufactured of these or any of them; for a strong caustic lye would entirely destroy the former, and convert them into a saponaceous matter.

By the means above described, or by another or different application of the volatile alkali or ammonia, the manner of performing which shall be immediately described, a degree of whiteness and purity may be given to cotton-wool, flax, hemp, silk, and sheep's wool, and to goods of every description made or manufactured of any of them, or of mixtures of all or any of them, which cannot otherwise be obtained but at a much greater expense.

When the volatile alkali is to be employed in place of that already described, that as little of the volatile alkali as possible may be lost, it is recommended, that instead of the safety-valve being affixed to some part of the steaming-kettle or of the steaming vat, or of the tube of communication between them, so as to allow the steam to escape when it acts with a certain force, it may be attached in such a manner that when opened by the internal pressure the vapour may not escape into the atmosphere and be lost, which would occasion a waste of the alkali, but may pass into a worm passing through a refrigeratory, that it may be condensed, and fall into a receiver adapted to the lower extremity of the worm. This part of the apparatus is exactly similar to that employed in the distillation of ardent spirits; but the receiver should be surrounded with cold water as well as the worm, the more effectually to condense the volatile alkali. The worm-tub and receiver may either be elevated higher than the steaming-kettle, for the purpose of returning the condensed alkali from time to time from the receiver into the steaming kettle, by means of a tube of communication and a stopcock between these two, in this manner to keep up a continual circulation

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of the volatile alkali; or they may stand at any convenient place at the side of the steaming-kettle or of the steaming-vat, and the condensed alkali, instead of being returned into the steaming-kettle, may be laid aside for other purposes, or for sale, as the way and manner in which the patentees obtain the volatile alkali and apply it to the purpose intended, and which constitutes a part of their invention, may sometimes render such sale advisable; that is to say, instead of employing volatile alkali or ammonia in the prepared state, as usually sold in commerce, they employ either urine or soot, or any substance containing it naturally, or which may be made to produce it by either putrefaction or lixiviation, or any of the common chemical processes that may not be too expensive for such an application and use.

Thus, if urine be the material employed for producing the volatile alkali, it should be allowed to stand till it putrefy or become stale; for which about a week's time in summer, and three or four weeks in cold weather, will generally be requisite; but, indeed, the longer the better. By this putrefaction an internal movement and new arrangement in the elementary principles of the urine is effected by nature so as to produce in it real volatile alkali, which only requires to be called forth and brought into action by the aid of proper means, of which the following may serve as an example:—To about eight parts of stale urine add one part of caustic or quick-lime, the fresher burnt the better; stir the ingredients, and allow them to rest for about six or eight hours, to give time to the sediment to settle at the bottom of the cask or other vessel in which the mixture is made. The clear liquor or lye may then be drawn off by a plug or cock at such a height from the bottom of the vessel as to allow the lye to run off without disturbing the sediment. By this means the volatile alkali which was formed in the urine by the putrefactive process is rendered caustic, the lime seizing on the carbonic acid which served to neutralise it and render it mild; and all that is now necessary is to put this lye into the steaming-kettle before described, and then, by means of heat, the whole alkali will disengage itself from the urine and pass into the steaming-vats, to exercise its action upon the goods deposited therein,

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which in this case may or may not be previously impregnated with an alkaline, soapy, or other lye.

If soot be the substance employed to furnish the volatile alkali, a lye must be prepared from it by lixiviation with water. For this purpose, a cask or other vessel should be provided with a double bottom, the upper one perforated with a number of small holes, and the space between the two filled with straw, or with any material which will lie open enough to allow the lixivium to percolate, and yet close enough to prevent the soot from passing with the clear liquor, such straw or other material being intended merely to perform the office of a filter. Into this cask or other vessel the soot is to be introduced above the double bottom, and water is to be thrown upon it, in which it should be allowed to remain for some hours; after which the water may be drawn off by a hole in the side close to the lower bottom of the cask or other vessel aforesaid, and will be found to have extracted a considerable quantity of volatile alkali from the soot, and to have become an alkaline lye, which, after being rendered caustic by the addition of about one pound of quick-lime to every eight pounds of the lye, may then be conveyed to the steaming-kettle, and applied to the purpose of bleaching, whitening, and purifying in the manner before directed respecting the lye prepared with stale urine and quicklime; or it may, before being rendered caustic, be again put upon a second and a third quantity of soot, and made to pass through them as at first to render it more alkaline, and being then rendered caustic by quicklime, as before directed, may be applied to the purpose aforesaid.

Where such simple and cheap materials as urine or soot cannot be procured in sufficient quantity, other substances may be employed for the production of the volatile alkali, or for extracting it from; or the common volatile alkali of commerce may be employed with the steaming-kettle, steaming-vat, and other apparatus before described, and which may be varied in form, shape, and arrangement, to answer the site and other circumstances connected with particular buildings.

The method of employing volatile alkali that has been specified will in every case be found to be more advantageous than

than any other that has heretofore been made use of, the action of the alkali being much more powerful when pent up in close vessels than when otherwise applied, and all waste being thereby prevented. Even the volatile alkali that may remain condensed in the fibre or tissue, or on the surface of the goods when taken from the steaming-vat, ought not to be lost. The goods should be rinsed in water to extract the alkali from them, and this water should be employed for the next lixiviation of the soot, where soot is made use of, or should be thrown into the steaming-vat, and the volatile alkali be separated from it by means of heat, and made to pass into the receiver before described, which will never require a long time or a waste of much fuel, being so much more volatile than the water that it soon passes over.

In the application of the volatile alkali, the goods may be taken from the steaming-vat or vats from time to time, and the operations of washing, steeping in acidulated waters, exposure to the sun and air, or to the action of oxygenated muriatic acid, be employed with advantage in such stages of the process as the bleacher may think proper, as has been above observed respecting the application of fixed alkaline, soapy, or other lyes, to the bleaching, whitening, and to the purifying and cleansing of the various goods above enumerated, by the use or through the medium of any apparatus constructed on the principles before stated. When cloth or garments are to be washed and cleansed by means of the steaming apparatus before specified, they may be impregnated with a strong solution of soap made from tallow, or from oil, or from fish, or from bones, or from wool, and with or without an addition of fixed alkali, and with or without the application of the volatile alkali in the manner before specified. It is only necessary further to observe, that oak should not be employed in the construction of the steaming-vat or other necessary vessel, nor any kind of wood that contains that substance known among chemists by the name of the *gallic acid*, and formerly called the astringent principle, because a portion of it might be dissolved in the lye, and would not fail to exercise its action upon the steaming-kettle if made of iron, (which is the best material for that vessel,) and would

produce

produce an ink more or less dilute, according to the quantity of gallic acid present, which, of course, would blacken the goods: nor should any kind of brass or copper be made use of in the apparatus, as the volatile alkali exercises so strong an action on these that they would be partially dissolved, and prove injurious to the process.

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## XLI. *A Treatise on the Cultivation of the Vine, and the Method of making Wines.* By C. Chaptal.

[Continued from page 268.]

### *IV. Of Fermentation.*

The must is scarcely put into the vat when it begins to ferment. That which flows from the grapes by the pressure or agitation they receive during the carriage, works and ferments before it arrives at the vat. This is a phænomenon which any one may easily observe by following the vintagers in warm climates, and carefully examining the must which issues from the grapes and remains mixed with them in the vessel used for carrying them.

The antients carefully separated the first juice, which can arise only from the ripest grapes, and which flows naturally by the effect of the slightest pressure exercised on them. They caused it to ferment separately, and obtained from it a delicious beverage, which they called *protopon. Mustums ponte defluens, antequam calcentur uvæ.* Baccius has described a similar process practised by the Italians: *Qui primus liquor non calcatis uvis defluit, vinum efficit virgineum non inquinatum fæcibus; lacrymam vocant Itali; cito potui idoneum fit et valde utile.* But this virgin liquor forms only one part of the juice which the grapes can furnish, and it cannot be treated separately, except when it is required to obtain wine very delicate and little coloured. In general, this first liquor is mixed with the rest of the grapes which have been trod, and the whole is left to ferment.

The vinous fermentation is always effected in vats of stone or of wood. Their capacity in general is proportioned to the

quantity

quantity of the grapes collected from one vineyard. Those constructed of mason work are for the most part of good cut stone, and the inside is often lined with bricks joined together by a cement of pozzolano or strong clay. Wooden vats require more care to maintain them, are more subject to variations of temperature, and liable to more accidents.

Before the vintage is put into the vat, care must be taken to clean it. It must therefore be washed with warm water and well scrubbed, and the sides must be covered with two or three strata of lime. This covering is attended with this advantage, that it saturates a part of the malic acid, which exists abundantly in the must, as we shall show hereafter.

As the whole process of vinification takes place during the fermentation, since it is by it alone that the *must* passes to the state of *wine*, we think it necessary to consider this important subject under several points of view. We shall first speak of the causes which contribute to produce fermentation; we shall then examine its effects or its product, and shall conclude with deducing, from what we actually know on the subject, some general principles which may direct the agriculturist in the art of managing it.

### *Of the Causes which have an Influence on Fermentation.*

It is well known that to establish fermentation, and make it follow all its periods in a regular manner, some conditions with which observation has made us acquainted are necessary. A certain degree of heat, the contact of the air, the existence of a sweet and saccharine principle in the must—such are nearly the conditions that are requisite; we shall endeavour to make known the effects produced by each of them.

#### 1. *Influence of the Temperature of the Atmosphere on Fermentation.*

The 54th degree of Fahrenheit is pretty generally considered as the temperature most favourable to spiritous fermentation; below that degree it is languid; above, it becomes too tumultuous. At a temperature too cold or too hot, it does not take place at all. Plutarch observed that cold could prevent fermentation, and that the fermentation of must was always

proportioned

proportioned to the temperature of the atmosphere *. Bacon recommends the immersion of vessels containing wine, in the sea, to prevent its decomposition. Boyle relates, in his Treatise on Cold, that a Frenchman, to keep his wine in the state of must, and preserve to it that sweetness of which some persons are fond, closed the cask hermetically and immersed it in a well or a river. In all these cases the liquor was not only kept in a temperature very unfavourable to fermentation, but it was secured from the contact of the air, which checks, or at least moderates, fermentation.

An extraordinary phænomenon, but which seems confirmed by a sufficient number of observations to merit full belief, is, *that fermentation is slower as the temperature has been colder at the time of collecting the grapes.* Rozier found in 1769 that grapes collected on the 7th, 8th, and 9th of October remained in the vat till the 19th without showing the least sign of fermentation: the thermometer in the morning had been at 3¼ degrees below freezing, and maintained itself at + 4. The fermentation was not completed till the 25th; while similar grapes collected on the 16th, at a temperature much less cold, terminated their fermentation on the 21st or 22d. The same thing was observed in 1740.

In consequence of these principles, it has been recommended to place the vats in covered places; to remove them from damp and cold places; to cover them, in order to moderate the cold of the atmosphere; to heat again the mass by introducing boiling must; and to make choice of a warm day for collecting the grapes, or to expose them to the sun, &c.

### 2. *Influence of the Air on Fermentation.*

We have seen in the preceding article that fermentation may be moderated and retarded by withdrawing the must from the direct action of the air, and keeping it exposed to a cool temperature. Some chemists, in consequence of these facts, are of opinion that fermentation can take place only by the action of the atmospheric air; but a more attentive observation of all the phænomena it presents in its different states will enable us to set a just value on all the opinions which have been entertained on that subject.

* Quæst. Nat. 27.

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The air, no doubt, is favourable to fermentation. This truth seems established by a concurrence of all the facts known: for, when preserved from the contact of the air, must will keep a long time without any change or alteration. But it is proved also, that though must shut up in close vessels undergoes very slowly the phænomena of fermentation, it at length terminates, and that the wine produced by it is more generous. This is the result of the experimets of D. Gentil.

If a little yeast of beer and melasses, diluted in water, be introduced into a flask with a bent beak, and if the beak of the flask be opened under a bell filled with water, and inverted over a pneumatic tub, at the temperature of 60 or 65 degrees; according to my observations, the first phænomena of fermentation will always appear a few minutes after the apparatus has been thus arranged; the vacuum of the flask soon becomes filled with bubbles and foam; a great deal of carbonic acid passes under the bell; and this movement does not cease till the liquor has become spiritous. In no case have I ever seen an absorption of atmospheric air.

If, instead of giving free vent to the gaseous matters which escape by the process of fermentation, their disengagement be checked by keeping the fermenting mass in close vessels, the movement then slackens, and the fermentation terminates only with difficulty and after a very long time.

In all the experiments which I tried on fermentation, I have never seen that the air was absorbed. It neither enters into the product as a principle, nor into the decomposition as an element; it is expelled from the vessels with the carbonic acid, which is the first result of the fermentation.

Atmospheric air, then, is not necessary to fermentation; and if it appears useful to establish a free communication between the must and the atmosphere, it is because the gaseous substances which are formed in the fermentation may then escape, by mixing with or dissolving in the surrounding air. It follows also from this principle, that when the must is put into close vessels, the carbonic acid will find obstacles to its volatilisation: it will be forced to remain interposed in the liquid; it will be dissolved there in part, and, making a continual effort against the liquid, and each of the parts of which it it is composed, it will slacken, and extinguish almost completely, the act of fermentation.

That fermentation therefore may be established, and pass through all its periods in a speedy and regular manner, there must be a free communication between the fermenting mass and the atmospheric air. The principles which are then disengaged by the process of fermentation easily enter the atmosphere, which serves them as a vehicle, and the fermenting mass from that moment may, without any obstacle, experience movements of dilatation and expansion.

If wine fermented in close vessels is more generous und more agreeable to the taste, the reason is, that it has retained the aroma and the alcohol, which are in part lost in fermentation that takes place in the open air; for, besides their being dissipated by the heat, the carbonic acid carries them to a state of absolute solution, as we shall show hereafter.

The free contact of the atmospheric air accelerates fermentation, and occasions a great loss of principles in the alcohol and aroma; while, on the other hand, the withdrawing of that contact slackens the movement, threatens explosion and rupture, and the fermentation requires a long time to be complete. There are therefore advantages and disadvantages on both sides; but perhaps it might be possible to combine these two methods with so much success as to remove all their disadvantages. This, no doubt, would be the highest point of vinification. We shall see hereafter that some processes practised in different countries, either for making brisk wines, or preserving to them a certain agreeable perfume, give us reason to hope for a more happy result of the labours that may be undertaken on this subject by persons of ability.

### 3. *Influence of the Volume of the fermenting Mass on Fermentation.*

Though the juice of the grape ferments in a very small mass, since I have made it pass through all its periods of decomposition in glasses placed on a table; it is nevertheless true, that the phænomena of fermentation are powerfully modified by difference of volumes.

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In general, fermentation is the more rapid, speedier, more tumultuous, and more complete, as the mass is more considerable. I have seen the fermentation of must in a cask not terminated till the eleventh day; while a vat filled with the same liquor, and containing twelve times the volume of the cask, ended on the fourth day. The heat in the cask never exceeded 70 degrees; in the vat it rose to 88.

It is an incontestable principle, that the activity of fermentation is proportioned to the mass; but we must not thence conclude that it is always of advantage to carry on the process of fermentation in a large mass, or that the wine arising from fermentation established in the largest vats has superior qualities: there is a term for every thing, and there are extremes equally dangerous, which must be avoided. To have complete fermentation, care must be taken not to obtain it with too great precipitation. It is impossible to determine the volume most favourable to fermentation; it even appears that it ought to be varied according to the nature of the wine and the object proposed. If it be the preservation of the aroma, it ought to be performed with a smaller mass than when it is required to develop all the spiritous part to make wines proper for distillation. I have seen the thermometer rise to 92 degrees in a vat containing thirty *muids* * of vintage Languedoc measure. In that case, indeed, all the saccharine principle is decomposed; but there is a loss of a portion of the alcohol by the heat and the rapid movement which the fermentation produces.

In general, the capacity of the vats ought to be varied according to the nature of the grapes. When they are very ripe, sweet, saccharine, and almost dry, the must has a thick consistence, &c. fermentation takes place with difficulty, and a great mass of liquid is required that the syrupy juice may be entirely decomposed; otherwise the wine remains thick, sweetish, and too luscious. It is only after being long kept in the cask that this liquor acquires that degree of perfection to which it is capable of ataining.

The temperature of the air, the state of the atmosphere,

* A *muid* contains 300 quarts, comprehending stalks, skins, and dregs.—E.



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and the weather which prevails during the vintage—all these causes and their effects must be always present in the mind of the agriculturist, that he may be able to deduce from them rules proper for directing his conduct in regard to this object.

### 4. *Influence of the constituent Principles of Must on Fermentation.*

The sweet and saccharine principle, water, and tartar, are the three elements of the grape which seem to have a powerful influence on fermentation: it is not only to their existence that the first cause of this sublime operation is due, but it is to the very variable proportions of these different constituent principles that we must refer the principal differences exhibited by fermentation.

1st, It appears proved, by comparing the nature of all the substances which undergo spiritous fermentation, that none are susceptible of it but those which contain a sweet and saccharine principle; and it is beyond a doubt that it is at the expense of this principle that alcohol is formed. By a consequence which naturally flows from this fundamental truth, bodies in which the saccharine principle is most abundant ought to furnish the most spiritous liquor. This is what is confirmed by experience. But it is impossible to insist too much on the necessity of making a careful distinction between *sugar* properly so called and the *sweet principle.* Sugar without doubt exists in grapes, and it is to it in particular that is owing the alcohol which results from its decomposition by fermentation; but this sugar is constantly mixed with a sweet body, more or less abundant, and very proper for fermentation: it is a real leaven, which almost every where accompanies sugar, but which by itself cannot produce alcohol. Hence it happens that, when it is necessary to ferment sugar in order to obtain rum, it is employed in the state of syrup called *vezou*, because it then contains the sweet principle which facilitates the fermentation.

The distinction between the sweet principle and sugar properly so called has been very well established by Deyeux in the *Journal des Pharmaciens.*

This sweet principle is almost inseparable from the principle

ciple of sugar in the products of vegetation; and these two principles are so well combined in some cases that they cannot be completely *disunited* but with difficulty. This is what will long prevent sugar, perhaps, from being extracted for commerce from several vegetables which contain it. The sugar-cane appears to be that of all the vegetables in which this separation is easiest. Many facts induce us to believe that this sweet principle approaches near in its nature to the saccharine principle; that, under favourable circumstances, it may even be converted into sugar: but the present is not the moment for discussing this important point.

Grapes, then, may be very sweet and very agreeable to the taste, yet produce very bad wine; because sugar may exist only in very small quantity in grapes which to appearance are highly saccharine. This is the reason why grapes exceedingly sweet to the taste do not always furnish the most spiritous wines. In a word, a very little practice is sufficient to enable us to distinguish the really saccharine savour from the sweet taste which some grapes possess. Thus the mouth habituated to taste the highly saccharine grapes of the south, will not confound with them the *chasselas*, though very sweet, of Fontainebleau.

We ought therefore to consider sugar as the principle which gives rise to the formation of alcohol by its decomposition, and sweet and saccharine bodies as the real leaven of spiritous fermentation. That must, then, may be proper for undergoing a good fermentation, it ought to contain these two principles in proper proportions: sugar alone does not ferment, or at least the fermentation of it is slow and incomplete. Pure mucilage does not furnish alcohol; it is only to the union of these two substances that we are indebted for good spiritous fermentation *.

2d, Very aqueous must, as well as too thick must, experiences fermentation with difficulty. A proper degree of fluidity, then, is necessary to obtain good fermentation; and this

* There are some mucous bodies capable of undergoing spiritous fermentation; but it is probable that these mucous bodies contain sugar which is more difficult to be extracted in proportion as the quantity is less.

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is presented by the expressed juice of grapes which have come to perfect maturity.

When the must is very aqueous the fermentation is slow and difficult, and the wine arising from it is weak, and very susceptible of decomposition. In this case the antients were accustomed to boil their must: by these means they caused the supernatant water to evaporate, and brought back the liquor to the proper degree of thickness. This process, always advantageous in the northern countries, and in general wherever the season has been rainy, is still practised. Maupin has even contributed to make this method be more adopted, in proving, by numerous experiments, that it may be used with advantage in almost all the wine countries. It however appears to be useless in warm climates; it is not applicable but in cases when the season having been rainy has not permitted the grapes to attain to the proper degree of maturity, or when the vintage has taken place during wet or foggy weather.

There are some countries where baked plastre is mixed with the grapes to absorb the excess of humidity they may contain. The custom established in other places of drying the grapes before they are fermented is founded on the same principle. All these processes tend in an essential manner to remove the humidity with which the grapes may be impregnated, and to present a thicker juice to fermentation.

3d, The juice of ripe grapes contains tartar, which may be shown in it merely by concentrating the liquor, as we have observed: but verjuice furnishes a still greater quantity; and it is generally true that grapes give less tartar the more sugar they contain.

The marquis de Bouillon extracted from $2\frac{1}{8}$ wine pints of must about 10 dwts. of sugar and $1\frac{1}{2}$ dwt. of tartar. It appears from the experiments of the same chemist, that tartar as well as sugar concurs to facilitate the formation of alcohol. To obtain three times as much ardent spirit, nothing is necessary but to increase the proportion of the tartar and the sugar.

The same chemist has also proved that must deprived of its

its tartar does not ferment, but that the property of fermenting may be restored to it by restoring to it that principle.

About 120 quarts of water, 100 ounces of sugar, and a pound and a half of cream of tartar, remained three months without fermenting. About 16 pounds of pounded vine-leaves were added, and the mixture fermented strongly for fifteen days. The same quantity of water and vine-leaves, left to ferment without sugar and without tartar, produced only an acidulous liquor.

In 500 quarts of cassonade and 10 pounds of cream of tartar fermentation was fully established, and continued forty-eight hours longer than in vats which contained simple must. The wine resulting from the first fermentation furnished one part and a half of brandy, at twenty degrees of Baumé's areometer, in seven parts which had been distilled; while the wine made without the addition of sugar or tartar produced only a twelfth part of spirit at the same degree.

Saccharine grapes require, in particular, the addition of tartar: it is sufficient for this purpose to boil it in a kettle with the must, in order that it may be dissolved. But when must contains tartar in excess, it may be disposed to furnish ardent spirit by adding to it sugar.

It appears, then, from these experiments, that tartar facilitates fermentation, and concurs to render the decomposition of the sugar more complete.

### *Phænomena of the Products of Fermentation.*

Before we enter into a detail of the principal phænomena exhibited by fermentation, we think it proper to trace out briefly the progress it follows in its periods.

Fermentation first announces itself by small bubbles which appear on the surface of the must; by degrees some are seen to arise from the centre even of the mass in a state of fermentation, and to burst at the surface; their passage through the strata of the liquid agitates all its principles, displaces all their moleculæ, and there soon results a hissing noise similar to that produced by a gentle ebullition.

Small drops, which immediately fall back, are then seen to rise several inches above the surface of the liquid. In that state the liquor is turbid, and every thing is mixed, confounded, agitated, &c.; filaments, pellicles, flakes, grapes, and stones, float separately, and are pushed, expelled, precipitated, and thrown up, till they at length settle at the surface, or are deposited at the bottom of the vessel. In this manner, and by a series of intestine movement, there is formed at the surface of the liquor a crust of greater or less thickness, called by the French *le chapeau de la vendange.*

This rapid movement and continual disengagement of these aëriform bubbles considerably increase the volume of the mass. The liquor rises in the vat above its primitive level. The bubbles, which experience some resistance to their volatilisation by the thickness and tenacity of the *chapeau*, force a passage to themselves in certain points, and produce abundant froth.

The heat increasing in proportion to the energy of the fermentation, an odour of spirit of wine is disengaged, and diffused every where around the vat; the liquor assumes a darker colour; and after several days', and sometimes even after a few hours', tumultuous fermentation, the symptoms decrease; the mass resumes its former volume, the liquor becomes bright, and the fermentation is almost terminated.

Among the most striking phænomena and the most sensible effects of fermentation there are four principal ones which require particular attention; the production of heat, the disengagement of gas, the formation of alcohol, and the coloration of the liquor.

I shall here speak of each of these phænomena, according to what we know of them with certainty from observation.

1st, *Production of Heat.*—It sometimes happens in cold countries, but particularly when the temperature is above 55 degrees, that the liquor put into the vat experiences no fermentation, unless some means can be found to heat the mass. This may be done by introducing into it warm must, stirring the liquor strongly, heating the atmosphere, or covering the vat with cloths.

But as soon as the fermentation begins the heat acquires intensity. Sometimes a few hours' fermentation is sufficient to carry it to the highest degree. In general it is in the ratio of of the swelling up of the mass; it increases and decreases like it, as will be proved by the experiments which I shall subjoin to this article.

The heat is not always equal throughout the whole mass; it is often more intense towards the middle, especially when the fermentation is not sufficiently tumultuous to mix and confound by violent movements all the parts of the mass: in that case the vintage is trod again; it is agitated from the circumference to the centre, and an equal temperature is established in every point.

We may admit as incontestable truths: 1st, That, at an equal temperature, the greater the mass of the vintage the greater will be the effervescence, movement, and heat. 2d, That the effervescence, the movement, and heat, are greater in vintage where the juice of the grapes is accompanied with the pellicles, stones, stalks, &c. than in must separated from all these matters. 3d, That fermentation can produce from 59 to 95 degrees of heat: at least, I have seen it in activity between these two extremes.

2d, *Disengagement of Gas.*—The carbonic acid gas disengaged from the vintage, and its effects hurtful to respiration, have been known since fermentation itself was known. This gas escapes in bubbles from every point of the vintage, rises in a mass, and bursts at the surface. It displaces the atmospheric air which rests on the vintage, occupies every where the vacant parts of the vat, and flows over the edges, precipitating itself in the lowest places on account of its gravity. It is to the formation of this gas, which takes a portion of oxygen and carbon from the constituent principles of the must, that we shall in future refer the changes which take place in fermentation.

This gas, retained in the liquor by all the means that can be opposed to its evaporation, contributes to preserve the aroma and a portion of alcohol which exhales along with it. The antients were acquainted with these means, and they carefully distinguished the product of a *free* from that of a *close* fermentation; that is to say, the fermentation effected in open and that effected in close vessels. Brisk wines are indebted for that quality to their having been shut up in the

 bottles

bottles before their fermentation was completed. This gas, being slowly developed in the liquor, remains compressed in it till the moment when, the effort of the compression having ceased, by the opening of the vessels it can escape with force.

This acid gas gives to all liquors impregnated with it a tartish savour. Those mineral waters called *gaseous waters* are indebted to it for their principal virtue. But it would be having a very incorrect idea of its real state in wine, to compare its effects to those which it produces by its free solution in water.

The carbonic acid disengaged from wine holds in solution a pretty considerable portion of alcohol. I think I was the first who made known this fact, when I showed that, by exposing pure water in vessels placed immediately above the *chapeau* of the vintage, at the end of two or three days this water is impregnated with carbonic acid, and that, to obtain very good vinegar, nothing is necessary but to put it into uncorked bottles, and to leave it to itself for a month. At the same time that the vinegar is formed, abundance of flakes, which are of a nature analogous to fibrous matter, are precipitated in the liquor. When water containing earthy sulphats, such as well-water, is employed instead of pure water, there is disengaged at the moment of acetification an odour of sulphurated hydrogen gas, which arises from the decomposition of the sulphuric acid itself. This experiment sufficiently proves that the carbonic acid gas carries with it alcohol and a little extractive matter; and that these two principles, necessary for the production of the acetous acid, being afterwards decomposed by the contact of the atmospheric air, produce acetous acid.

But is the alcohol dissolved in the gas, or is it volatilised merely by the heat? This question cannot be determined by direct experiments. Gentil observed in 1779, that when a glass bell was inverted over the vintage in fermentation, the inside of it became covered with drops of a liquid which had the smell and properties of the first phlegm that passes when spirits are distilled. Humboldt has proved that if the vapour of champagne be received under bells, in an apparatus for collecting gas, surrounded with ice, alcohol is precipitated on the

the sides merely by the impression of the cold. It appears, then, that the alcohol is dissolved in the carbonic acid gas, and it is this substance which communicates to the vinous gas a part of its properties. Every one feels, by the impression which the vapour of champagne makes on our organs, how this gaseous matter is modified, and differs from pure carbonic acid.

It is not the most saccharine must that furnishes the most gaseous acid, nor is it that employed in general for making the briskest wines. If the fermentation of this kind of grapes were checked by shutting them up in casks or jars to preserve the gas disengaged from them, the saccharine principle, which abounds in them, would not be decomposed, and the wine would be sweet, luscious, thick, and disagreeable. There are some wines all the alcohol of which is dissolved in the gaseous principle: that of Champagne furnishes a proof of it.

It is difficult to obtain wine red and brisk at the same time; especially as, to make it acquire colour, it must be suffered to ferment over the skins, stalks, &c.; and as by these means the acid gas is dissipated.

There are some wines the slow fermentation of which continues for several months. These, if put into bottles at the proper time, become brisk: there are none, strictly speaking, but wines of this kind capable of acquiring that property. Those the fermentation of which is naturally tumultuous terminate this process too soon, and would break the vessels in which they are inclosed.

This acid gas is dangerous to be respired. All animals exposed to it are suffocated. Such melancholy accidents are much to be apprehended when the vintage is made to ferment in low places where the air is not renewed. This gaseous fluid displaces the atmospheric air, and at last fills the whole cellar. It is the more dangerous as it is invisible like air; and too much precaution cannot be taken against its fatal effects. To ascertain whether there be any danger, those who enter a place where vintage is in a state of fermentation ought to cause a lighted candle to be carried before them: if the candle continues burning, there is no danger; but if it is seen to grow dim, and then to go out, it will be prudent to retire.

This danger may be prevented by saturating the gas in proportion as it is precipitated on the floor, by scattering in several places milk of lime, or quicklime. A place rendered noxious by this pernicious gas may be purified by throwing upon the floor and against the walls quicklime diluted in water: a caustic alkaline ley, such as soapmakers' ley or ammonia, will produce a similar effect. In all cases the gaseous acid instantly combines with these matters, and the external air descends to occupy its place.

3d, *Formation of Alcohol.*—The saccharine principle exists in must, and makes one of its principal characters: it disappears by fermentation, and is replaced by alcohol; which essentially characterizes wine.

We shall mention hereafter in what manner this phænomenon, or this interesting series of decompositions and productions, may be conceived. Our business at present is to indicate the principal facts which accompany the formation of alcohol.

As the object and effect of spiritous fermentation are merely the production of alcohol by decomposing the saccharine principle, it thence follows that the formation of the one is always in proportion to the destruction of the other, and that the alcohol will be more abundant as the saccharine principle is greater: for this reason, the quantity of alcohol may be augmented at pleasure by adding to the must the sugar which seems to be wanting.

It invariably follows from these principles, that the nature of the vintage in fermentation is every moment modified and changed: its smell, taste, and other characters, are continually varying. But as there is a very constant progress in the process of fermentation, it may be followed in all its changes, which may be considered as invariable signs of the different states through which the vintage passes.

1st, Must has a sweetish odour, which is peculiar to it. 2d, Its savour is more or less saccharine. 3d, It is thick, and its consistence varies according as the grapes are more or less ripe, more or less saccharine. I have found by experience that some marked 75 degrees of the areometer, and others only from 40 to 42. It is exceedingly soluble in water.

Scarcely

Scarcely is the fermentation determined when all the characters are changed: the odour begins to become pungent by the disengagement of carbonic acid; the savour, still very sweet, is however already mixed with a little of the pungent; the consistence decreases; the liquor, which hitherto presented only one uniform whole, exhibits flakes which become more and more insoluble.

The saccharine savour becomes gradually weaker, and the vinous stronger: the consistence of the liquor is sensibly lessened: the flakes detached from the mass are more completely insulated. The odour of the alcohol is perceived at a greater distance.

At last the moment arrives when the saccharine principle is no longer sensible; the savour and smell now indicate nothing but alcohol: all the saccharine principle, however, is not destroyed; a portion of it still remains; the existence of which is not masked by that of the predominant alcohol, as is confirmed by the very correct experiments of Gentil. The further decomposition of this substance takes place by the aid of the tranquil fermentation which is continued in the casks.

When the fermentation has passed through, and terminated all its periods, no more sugar exists; the liquor has acquired fluidity, and presents only alcohol mixed with a little extract and colouring principle.

4th, *Coloration of the vinous Liquor.*—The must which flows from the grapes transported from the vineyard to the vat before they have been trod, ferments alone, produces *virgin wine*, the *protopon* of the antients, which is not coloured.

Red grapes, the juice of which is expressed by mere treading, always furnish white wine when not fermented with the skins, stalks, &c.

Wine becomes more and more coloured as the vintage remains longer without being fermented. Wine is less coloured as the grapes have been less trod, as greater care has been taken to cause them to ferment in the skins, &c.

Wine is more coloured as the grapes are riper and less aqueous.

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The liquor furnished by the skins, &c. when subjected to the press is less coloured.

The southern wines, and, in general, those made from grapes collected in places well exposed to the south, are more coloured than the wines of the north.

Such are the practical axioms which have been sanctioned by long experience. Two fundamental truths thence result: the first is, that the colouring principle of wine exists in the skins of the grapes; the second is, that this principle does not detach itself, and is not completely dissolved in the vintage but when the alcohol is developed in it.

We shall treat in the proper place of this colouring principle, and shall show, that though it approaches resins in some of its properties, it is, however, essentially different.

Any one, after this short explanation, may account for all the processes usual for obtaining wines more or less coloured; and may readily conceive that it is in the power of the agriculturist to give to his wines whatever tint of colour he chooses.

[To be continued.]

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## XLII. *Researches respecting the Laws of Affinity.* By C. Berthollet, *Member of the French National Institute.*

[Continued from p. 153.]

### X. *Of the Determination of Elective Affinities.*

To determine the elective affinity of two substances for a third, according to the idea which we ought to form of it, is to ascertain in what ratio this third substance ought to divide its action between the two former, and at what degree of saturation each of them ought to be when their forces are equally opposed. The respective affinities will be proportional to the degree of saturation which each has attained in proportion to the quantity which has acted; so that, if the quantities are equal, the comparative degree of saturation will give the measure of the respective affinities.

2d, When I speak of the saturation of a substance, I do not

not mean the absolute saturation at which all reciprocal action would cease; but a degree of saturation which it is easy to ascertain, and which is common to all combinations: it is that of neutralisation, when the properties of neither of the constituent parts predominate. The term of the crystallization of salts does not always coincide with neutralisation: for example, in regard to alkaline carbonats, which still give signs of alkalinity, and in regard to the acidulous tartrite of potash, which, on the other hand, retains an excess of acid. The last combination, however, may be taken at the term at which it is neutral, because it still has the property of crystallization: it is even this tartrite that is necessarily obtained when in the experiment there is present an excess of the base; but when there is an excess of acid, the degree of saturation of the acidulous tartrite of potash may be determined by the quantity of potash necessary to neutralise it.

3d, A consideration which seems to deserve some attention is, that in comparing affinities it would be necessary to employ in all the experiments the same proportions of all the substances successively subjected to operation; because, if the proportions vary, the result of the action not being the same, the affinity could no longer be represented by the same number. I shall render this observation more sensible by an example:

Let 100 represent the potash, which ought to be saturated by 100 parts of sulphuric acid, and let 100 parts of soda be opposed to it. Let us suppose that after the action it is found that the potash has taken up 60 parts of acid, and the soda 40, I should thence conclude that the affinities of these two bases for the sulphuric acid are in the ratio of 60 to 40: but there remain 40 parts of potash uncombined, which really continue to act, and which by their action contribute to divide the acid; so that, if this quantity be varied, the result cannot be the same; for, if, instead of 100 parts of potash and 100 parts of soda, we take 80 parts of each, we shall have for the uncombined portion 20 parts of potash and another quantity of soda; so that the forces exercised by these two parts are no longer in the former ratio: hence it results that the two saturations cannot be in the ratio of 60 to 40.

4th, But to ascertain the degree of saturation to which each of these substances can attain, a separation must be made, which can only be effected by the elasticity, crystallization, precipitation, or action of a solvent: but we have seen that these different means ought to be considered as foreign forces, which alter the results, and which determine the combinations formed, without a possibility of our measuring their effect so as to disengage from it that of the elective affinity; so that the separations which in articles I. II. III. were considered only as an effect of elective affinity and of proportions, are really the effect of a concourse of several forces, as is proved by the observations which followed these articles.

When it is necessary, for example, to ascertain the quantity of the sulphat of potash and of soda formed, as the force of cohesion of these two sulphats does not much differ, it is probable that it would not occasion much change in the proportions of the two salts which would crystallize, but it would be necessary to separate the excess of the alkali by means of alcohol in order to obtain the whole crystallization; but alcohol not acting with equal force upon potash and soda, would produce a new change. To these considerations we may add, that a change of proportions would not only make the force of the soda and the potash (No 1.) to vary, but also that of the alcohol, not to mention the affinity of the water, which serves as a solvent.

If barytes were to be compared with either potash or soda, we should have changes still more considerable: in that case, the force of cohesion of the sulphat of barytes would be such that it would leave to the alkali but a very small quantity of sulphuric acid, which would be the expression of the ratio of the force of the cohesion of the sulphat of barytes to that of the solvent, rather than of the affinity of the barytes to that of the alkali.

This is so certain, that if, with the view of comparing the affinity of the acids for barytes, we should begin by treating the barytes with an excess of sulphuric acid, it would be almost entirely precipitated, unless the acid were highly concentrated; it would even be impossible to distinguish the combined

combined portion from that which is not, and to say that the barytes has more affinity for the former than for the latter. This, however, is what is really said when it is affirmed that the sulphuric acid has more affinity for the barytes than any other acid has, because a sulphat of barytes is formed by precipitation; and thus an effect, which depends in particular on the force of cohesion peculiar to the sulphat of barytes, is ascribed to elective affinity.

It is manifest, therefore, that the elective affinity of two substances in regard to a third, cannot be determined by a direct experiment even when trial is made on two substances which are in a liquid, and which may become neutralised by saturation; since, in order to ascertain the saturation, it is necessary to employ the intervention of foreign forces.

5th, We have shown in articles II. and III. that the affinity of a substance may be compensated by its quantity.

From this consideration it would appear that it is sufficient to ascertain the capacities of saturation of different bases for an acid, or of different acids for a base, in order to establish the ratio of their affinity; for it ought to be in the inverse ratio of the quantities necessary to produce the same degree of saturation.

This consequence, however, is erroneous when we are desirous of applying it to the elective affinities; because, as soon as the two substances are put in circumstances to combine with a third, new forces are established, which not only determine other results, but even change the constitution of these substances. Thus, if we compare the sulphuric acid with carbonic acid, it is certain, that if a quantity of potash be brought to the term of neutralisation by carbonic acid, it exercises a force as great as the quantity of sulphuric acid which would be necessary to produce the same effect: and yet if sulphuric acid be poured on the combination thus formed, all the carbonic acid is disengaged; because, not being retained by an equal force, it resumes the elastic state; and even if it be retained by a sufficient quantity of water, it will no longer be in the same state of compression; it will no more have the same constitution; it will no longer be the same substance in regard to chemical action. In a word, we must apply to the action of substances unequally saturated the observations made in the preceding articles.

A comparison, then, of the capacities of saturation, though it may conduct to important considerations, cannot be applied to the determination of elective affinities.

### XI. *Of some Errors which arise from a false Idea of Elective Affinity.*

1st, I shall here discuss some opinions adopted respecting elective affinities: I shall show how little foundation they have, and shall oppose to them the application of principles established in the preceding articles.

Baumé observed that when the sulphat of potash was dissolved by means of heat, in an equal weight of nitric acid, crystals of nitrat of potash were obtained by cooling. He ascribes this decomposition of the sulphat of potash to reciprocal affinities, which produce opposite combinations without determining the cause of this contrary effect.

2d, The explanation of this remarkable fact has been contradicted by Bergman. He observes that there are salts which tend to have an excess of acid, such as the acidulous tartrite of potash. He is of opinion that, when these salts are in a state of neutralisation, we must consider their base as divided into two parts; one upon which the whole action of the acid is particularly exercised to form an acidulous salt, while the other part only tends to satisfy the excess of acidity in the acidulous salt. This part of the base is retained then only by a weak acidity, and it may be taken away by an acid very inferior to that which enters into the first combination. Thus the acetous acid may take away part of the potash, which in the tartrite of potash is superfluous, to the combination that constitutes the acidulous tartrite of potash, though this acid has a much weaker affinity than the tartareous acid.

But the sulphat of potash is among the number of those salts which tend to form an acidulous salt; nearly two-thirds of its base enter into this combination, and it is only this portion which is subject to all the affinity of the sulphuric acid; the other third may be separated by an acid of an affinity inferior to that of the sulphuric acid, such as the nitric, muriatic, or tartareous acid. When the decomposition is carried to its boundary, it stops, whatever may be the quantity of the acid opposed; and if the quantity is not too great to prevent crystallization, or if the excess be expelled by heat, an acidulous sulphat, which forms crystals permanent in the air, will be obtained by solution and evaporation.

3d, How could the illustrious Bergman deviate from the route traced out to him by observation? His own experiments, even, prove that the acid, which is superabundant in the acidulous sulphat of potash, exercises its affinity; that it is in combination; and that it acts in the ratio of its quantity: for he says, that if sulphuric acid be added to the acidulous sulphat of potash, this salt dissolves, and loses its property of crystallizing; that this excess of acid can with difficulty be expelled even by distillation in a retort; and that, to produce this effect, the saline combination must be fused in a crucible, or be exposed several times to the action of very pure alcohol.

4th, The limit, then, which Bergman gives to the action of acids on the acidulous sulphat is ideal. This sulphat exhibits the same phænomena as all the salts which are capable of resisting, to a certain degree, the action of an excess of acid or base (Art. V. No. 4.), as well as the action of another acid or a foreign base. The only difference there is between them in this respect depends on the force of cohesion which may act more or less to produce crystallization, and which is proper to certain proportions of acid and base; probably a consequence of the figure assumed by the moleculæ of their combination.

5th, When an acid has the property of forming a precipitate by combining with a base, it is concluded that it has more affinity for that base than for the acid with which it was first united, without examining how far the new acid may have operated the decomposition, and without reflecting that an opposite decomposition takes place by a simple change of proportions, and might consequently conduct to an opposite conclusion.

Thus, as the tartareous acid has the property of forming, with potash, an acidulous salt very little soluble, and consequently forms a precipitate with all salts having a base of

 potash,

potash, and not diluted with too large a quantity of water, it has been concluded that it has more affinity for potash than the other acids. Bergman has excepted the sulphuric acid, because he supposed that the tartareous acid could act only on the potash redundant to the combination of the acidulous sulphat of potash; a supposition which I think I have already destroyed in the preceding articles. He has excepted also the nitric and muriatic acids, because he supposed that the tartareous acid showed the same phænomena in regard to the nitrat and muriat of potash as in regard to the sulphat; though he has not ascertained the existence of an acidulous nitrat and muriat of potash analogous to the acidulous sulphat of potash.

He also concludes, from experiments made on salts having a base of soda, but without making the experiments known, that the tartareous acid ought to be placed after the oxalic acid: but, not to dwell on these exceptions, the tartareous acid, according to him, decomposes completely all the other salts with a base of fixed alkali.

What embarrasses Bergman is, that the tartareous acid produces no precipitate with salts that have a base of soda. In his opinion, this apparent difference depends on the soda not having the property of forming a salt but little soluble, by taking up an excess of acid; but in that case there is no evidence of a decomposition, and we are to be satisfied with the probability that the affinities of the one fixed alkali follow the same order as those of the other.

All this classification of affinities is founded on the false supposition, that one acid expels another from its combinations by its affinity alone considered as a constant force; and this supposition renders others necessary in order to explain, as exceptions, those facts necessarily arising from a general property.

6th, I have examined the decomposition of acidulous tartrite of potash by the nitric acid, which, according to the received ideas, which I then adopted, ought to decompose it by seizing entirely on its base. I digested acidulous tartrite of potash and nitric acid, and obtained, by cooling, beautiful crystals of nitrat of potash. I repeated the operation several times,

times, adding nitric acid until no more nitrat of potash was separated. I then exposed the liquor to a heat sufficient to cause the nitric acid which might be free, to evaporate without altering the tartareous acid. After this the liquor had an oily consistence; it was destitute of smell, and announced neither the existence of nitric acid nor that of potash; but when exposed to a strong heat there was disengaged a great deal of nitrous gas, the tartareous acid was reduced to charcoal, and its ashes gave a considerable quantity of carbonat of potash.

7th, In this operation there is separated a part of the nitrat of potash, effected by the crystallizing force of that salt, and carried by it just to the degree when that force is exceeded by the superabundant acid. The acidulous tartar is rendered soluble by the action of the nitric acid, which takes from it at the same time, by crystallization, a part of the base necessary for its insolubility.

On the other hand, tartareous acid added to a solution of nitrat of potash, takes up, to a certain term, the potash from the nitric acid, and forms an acidulous tartrite, which is precipitated; but, as it has not the property of forming an acidulous tartrite of soda little soluble, it does not produce a precipitate with salts having a base of soda.

In both these cases, every thing that cannot be separated by the force of cohesion forms a liquid, in which the substances exercise an action proportioned to their present masses.

Nothing, then, can be concluded in regard to the respective affinity from these separations, which are effected by precipitation or crytallization; since, by the change of the proportions alone, opposite decompositions may be often obtained.

8th, The precipitation observed to take place, when, in comparing the affinities of two bases, one of them was found to have formed an insoluble combination, gave rise to an error of the same kind; and it is on this foundation alone that it has been asserted that lime has more affinity than alkali for the fluoric, phosphoric, and arsenic acids: in a word, for all those which form with it an insoluble combination; and, consequently, that it has the property of decomposing entirely the salts formed by an alkali and these acids.

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This precipitation is not the result of elective affinity, and it is not complete, but its quantity is determined by the ratio of the action of the liquid to the cohesive force of the precipitate: hence it happens that the precipitate is often re-dissolved on augmenting the quantity of the substance opposed to it.

9th, Though Bergman has explained very clearly the changes which heat may produce on chemical action when the substances have a disposition to volatilisation; and though he even recommends to avoid too strong heat in evaporation, the extent of the influence which it may have in the operations by which salts are separated, in order to form a judgement of their affinities, has not yet been fully discovered.

It ought not to have been concluded that the sulphuric acid has more affinity for fixed alkalies than the nitric or muriatic acids, merely because that by a strong heat it expels these acids from their combinations. Chemists should have observed that, even by the heat employed to produce evaporation, and to cause salts to crystallize, the proportions of the volatile acids may be considerably changed in regard to the sulphuric acid which remains opposed to them, and that the latter may at length entirely expel them, by means of the difference which exists between its fixity and that of these acids. (Art. VII. No. 5.)

10th, We are indebted to Bergman for useful observations on the errors which may arise from the solubility of one substance, which is eliminated, and of which the separation is not observed. He remarks that potash and soda do not disturb the transparency of the solution of a salt with a base of lime, if this solution be diluted with fifty times as much water, because the lime separated, being soluble, remains in the water; but he did not reflect that, if the lime, in that case, had no more than its natural solubility, it would be a very weak obstacle to its precipitation, for it requires nearly seven hundred parts of water to dissolve it: what adds greatly to its natural solubility is, that it continues to be in combination with the acid (Art. V. No. 5.), and that it cannot be separated but by retaining a part (Art. III. No. 9.), which increases its solubility.

11th,

11th, Notwithstanding his general observations, Bergman mistook the effects of solubility in several cases: thus, he did not think that the nitric and muriatic acids had an action on the combination of the phosphat of lime, though the only difference that can be established in this respect between these two acids and the sulphuric acid, the comparative force of their affinities not being known, is, that the two former form only soluble combinations, while that produced by the sulphuric acid may be withdrawn, in a great measure, by the force of crystallization.

12th, It is the solubility of the lime as well as of the barytes, increased by the action of the acid on these earths, which causes ammonia not to produce any precipitate in the solution of the salts of which they are the base. The first portion of the ammonia, however, mixed, for example, with the muriat of lime, scarcely suffers any odour to be exhaled; which indicates that it has entered into combination, and that its action may be rendered sensible, as shall be here shown.

I mixed ammonia with a solution of the muriat of lime, and I caused the liquor to evaporate in a retort: when it was reduced to a certain point, there was formed a pretty considerable precipitate. I continued the operation, at the end of which the quantity of the precipitate was very much diminished; there was formed a pellicle; and by cooling, a large quantity of crystals in pretty long needles. It was a triple salt, from which the ammonia could be disengaged by lime. This salt, when redissolved, and evaporated in the open air, gave no more indications of ammonia in the proof by lime.

It is seen, then, that, when the water has not been too abundant, the ammonia precipitated a part of the lime, though it was rendered much more soluble by the acid, and though the action of the ammonia was considerably weakened by the heat, which diminished its affinity and its quantity. In proportion as the latter was reduced, the precipitate was re-dissolved: there however still remained ammonia after a long evaporation, and it was only by the help of the action of the air that it was entirely dissipated. The separation of the

the lime would, no doubt, become much more sensible if the ammoniacal gas were received in a strong solution of the muriat of lime.

If the ammonia produces a precipitate with salts having a base of alumine, it is because this earth has less solubility than lime, even when it is combined with the portion of the acid which it retains while it is precipitated.

[To be continued.]

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## XLIII. *Experiments and Remarks on Galvanism. A Letter from a Correspondent to the Editor.*

SIR,

HAVING read with much pleasure, in your very valuable monthly publication, the several opinions and experiments respecting the influence excited in the pile of Volta, I take the liberty of submitting to you some observations on the same subject.

It has been said by some very ingenious experimentalists that the oxydation of one side of the plates, or the difference of oxydation in the two metals, or between one metal and different fluids, is the cause of the production of the galvanic influence. I find that the acids increase the power of my pile, and I also find, when the papers or cards are moistened with the pure alkalies, and particularly with a solution of pure ammonia, that the effect is much greater than by any other substance. This fact is, I believe, sufficient to prove that the oxydation of the metals is not the cause of the phænomenon.

It is very convenient to use the alkalies in this manner, as it does not require so much trouble to clean the metals, or to keep the pile in order.

I took ten saucers, and placed in each a plate of silver and a plate of zinc; I connected these metals in the several saucers together, by means of slips of tin-foil, and completed the circuit by means of wires in water. I first filled these saucers with salt and water, and found that the wires in the water produced a trifling effect: some few air-bubbles escaped, which proved that the influence was excited. I then removed

moved the salt and water, and substituted in its stead an aqueous solution of pure potash in water: a much greater effect was produced in the liquid through which the circuit was made. On the addition of water of pure ammonia, the effect was very strong.

You will observe that in these experiments I employed the decomposition of water (as it is called), by means of platina wires, as a galvanometer.

As I found that the water of pure ammonia succeeded so well in the saucers, I built up my pile, interposing pieces of blotting-paper moistened with this alkali: I was astonished at the increase of power; with fifty or sixty pieces of silver it was much too strong to be agreeable. A person above six feet high, and very strong, started several paces on receiving the shock, although he knew he was to receive one; and this after the pile had been constructed five hours. I mention these facts thus particularly, because I wish to show that the fluid excited in the pile does not arise from the action of acids, or from any combination of oxygen with the metals.

The next subject to which I wish to draw your attention is, the effect which this new agent will have on the prevailing theory of chemistry. The advocates for the Lavoisierian hypothesis say that it decomposes water. The facts which are already before the public, completely, in my opinion, unsettle that doctrine. In your last Number, Dr. Moyes mentions that the influence will not continue to decompose the water after it has been acted on to a certain point. I have kept my two platina wires in the same small quantity of water for months, and I find that when connected with my pile, the gases are produced as rapidly as when they were first used.

Indeed, now that I use the water of pure ammonia, they pour forth very large quantities. If a syphon be made to connect two glasses of water, and in each be placed a wire, one connected with the zinc and the other with the silver, the gases are produced. If a particle of water is composed of a particle of oxygen and a particle of hydrogen, what rapid currents must there be of those two substances! Where the oxygen is produced, the hydrogen must first descend to the bottom of the leg of the syphon, pass through it, and appear at the wire in the other glass, and *vice versâ* with the oxygen; for, where each appears, there is not the slightest trace of its former concomitant in the particle of water.

The visionary hypothesis* of oxygen and hydrogen being the bases of certain gases, the one a principle of acidity and the other the generator of water, in their combinations also with another substance, azot, forming atmospheric air, nitrous acid, gaseous oxyd, &c.; with carbon also forming all the substances of the animal and vegetable kingdoms, must now, in concurrence with the hitherto invariable opinions of some of our most learned philosophers, be entirely abandoned.

From the experiments with the pile, it appears that the difference between vital and inflammable air does not arise from any difference between their ponderable parts, those being in both instances water. A question arises respecting the minus side of the pile. How is it that, by abstracting electricity (which must be the case if the negative side be only deficient in quantity) from the water, that water is changed into an highly elastic aëriform fluid, into oxygen air, which of all airs, according to M. Lavoisier, has the greatest capacity for containing caloric? Surely the abstraction of fire, though it should be in the form of electricity, could not change water into so highly an elastic substance as oxygen air.

The following conclusions appear to me to result from what I have read and seen respecting the pile of Volta.

The oxydation or rusting of the metals in the pile does not appear to be the cause, but the consequence, of the influence. As the rusting of the metals diminishes and destroys the power of the pile, I conceive the pure alkalies to act by reaching the pure metals.

Water is not decomposed when forming part of the cir-

* The admitted facts in philosophy had been so well canvassed by the adherents of the new and the old systems of chemistry before we commenced our work, as to enable us to steer pretty clear of all controversy in conducting it. New facts, however they may operate, demand the attention of philosophers; and those connected with galvanism, in particular, may serve to clear up some parts of a theory, which, if not perfect, deserves, at any rate, a more respectful epithet than that of being *a visionary hypothesis*.—Edit.

cuit,

tuit. Oxygen and hydrogen airs have the same basis, water. Oxygen and hydrogen, as solid bases, are, consequently, nonentities. Positive and negative electricity are distinct fluids.

As these two electricities change water into two airs, and as those airs can from water be obtained in any proportion, and as those airs can be united, and again form water and fire; I consider those electricities as the principles of fire.

I consider, therefore, that the influence is excited by the decomposition of heat, caloric, or fire; as the tourmalin decomposes it by merely heating it.

The elastic state of aëriform bodies does not depend so much on the quantity of what is termed *latent heat*, as on the nature of one of the principles of heat which it contains. The solid oxygen, according to the Lavoisierian hypothesis, in nitre, contains as much latent heat as in the state of gas.

Put a piece of red-hot iron on an electrometer, and drop a little water on it, does not hydrogen air escape? Now, as positive electricity and water form hydrogen air, does not the electrometer show signs of negative electricity?

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## XLIV. *On the Manufacture and constituent Parts of Gunpowder. Read before the Askesian Society May* 1801. *By Mr.* R. Coleman, *of the Royal Mills, Waltham Abbey; a corresponding Member of the Society.*

THE process of manufacturing gunpowder is so inaccurately described in every author which I have seen, and in many instances so extremely absurd an account is given, that I am induced to hope that a true account thereof will not be unacceptable; and more particularly as I apprehend nothing can tend more to establishing a true theory of the combustion of gunpowder, than a knowledge of the ingredients it is composed of, and the manner of their combination. With this view I have drawn up the following account of the process, &c. in manufacturing that article, and added some facts on the explosive force thereof, which I now beg to lay before the Society.

## *On the Invention of Gunpowder.*

Gunpowder has for ages been known in the East, particularly in China, and, it is said, has been in use there ever since the year 85.

The first introduction of gunpowder into Europe has generally been ascribed to Roger Bacon, who wrote a treatise in 1280, in which we find the first hints for the application of it to the purposes of war. In 1320, Bartholomew Schwartz, a monk, is said to have re-invented it in Germany, by accidentally pounding in a mortar the ingredients of which gunpowder is made, and into which a spark of fire falling, blew the mortar to pieces. This opinion has lately been contradicted in France by Citizen Langles, who contends, in a memoir read in the French National Institute, that the knowledge of gunpowder was conveyed to us from the Arabs on the return of the crusades into Europe, and that the Arabs made use of it at the siege of Mecca in 690; that they derived it from the Indians, who, in their sacred books forbidding the use of it in war, may reasonably be concluded to have known it for ages.

However this may be, it seems probable that gunpowder was early known in India; for in whatever country nitre abounds, there its deflagrating quality is likely to be observed. Sir George Staunton observes: "The knowledge of gunpowder in China and India seems coeval with the most distant historic events. Among the Chinese it has at all times been applied to useful purposes, as blasting rocks, &c. and in making of fire-works; although it has not been directed through strong metallic tubes, as the Europeans did soon after that they had discovered it."

The honourable George Napier procured some gunpowder made in China, and on the average analysis of two ounces of it (960 grains), he found it to consist of saltpetre 720 grains, charcoal 141 grains, and sulphur 89 grains. Here is a deficiency of 10 grains in the process. Now, admitting the deficiency to be in equal proportions to each ingredient, and bringing the same to the proportion of 100 parts of gunpowder, there will be,

Saltpetre

| | | |
|---|---|---|
| Saltpetre | - | 75,7 |
| Charcoal | - | 14,4 |
| Sulphur | - | 9,9 |
| | Total | 100 |

If this is the case, it will be seen that their proportion differs very little from the English proportion.

Having thus given a brief account of the invention, I shall now proceed concisely to give the

## *Process of manufacturing Gunpowder.*

Gunpowder is made of three ingredients, saltpetre, charcoal, and brimstone. They are combined in the following proportions: to each 100 parts of gunpowder, saltpetre 75, charcoal 15, and sulphur 10.

The first thing to be attended to, it is evident, is the purity of these articles; for, if they are defective, the gunpowder can never be good, though ever so well manufactured.

The saltpetre is either that which has been imported, principally, from the East Indies, or that which has been extracted from damaged gunpowder. It is refined by solution, filtration, evaporation, and crystallization; after which it is fused, taking care not to use too much heat, that there may not be any danger of decomposing the nitre; by this means it is not only rendered more pure, but the water of crystallization more certainly got rid of. The principal object in refining the nitre is, to get it free from the earths and salts it is combined with in its *grough** state, and which by deliquescing would render the gunpowder liable to injury by attracting moisture, and, thereby decomposing the accurate mixture of the composition, rendering it unfit for use.

The sulphur used is that which is imported from Sicily, and is refined by melting and skimming: the most impure is refined by sublimation.

The charcoal formerly used in this manufacture was made by charring wood in the usual manner. This mode is called *charring in pits.* It consists in the wood being cut into lengths of about three feet, and then piled on the ground in a circular

* This is the term used for the nitre as imported.

form

form (three, four, or five cords of wood making what is called a pit), and covered with straw, fern, &c. kept on by earth or sand to keep in the fire, giving it air by vent-holes as may be found necessary. This mode of charring is uncertain in its operation, and defective in every respect for the purpose of making good charcoal; and therefore no dependance could ever be placed on the charcoal so made.

The method now adopted for making charcoal for gunpowder, consists in distilling (if I may so call it) in iron cylinders and collecting the pyro-ligneous acid, the carbon remaining in the cylinder or retort. The wood to be charred is first cut into lengths of about nine inches, and then put into the iron cylinder, which is placed horizontally. The front opening of the cylinder is then closely stopped: at the further end are pipes leading into casks. The fire being made under the cylinder, the pyro-ligneous acid, attended with a large portion of carbonated hydrogen gas, comes over. The gas escapes, and the acid liquor is collected in the casks. The fire is kept up till no more gas or liquor comes over, and the carbon remains in the cylinder.

This, it is evident, is a more eligible method than the former; and, indeed, the only proper one. The difference in the strength of the powder made from the two sorts of charcoal will be more particularly mentioned hereafter. I shall here only remark, that the proportion of powder used for the several pieces of ordnance by the navy, &c. has been reduced one-third in consequence of the increased strength of he composition into which this cylinder charcoal enters.

The wood, before charring, has the bark taken off; for which purpose it is felled in the summer season, when the sap is up, and it will flow clean. One reason for taking off the bark is, that it would render the powder therefrom full of sparks; which would be of course injurious, and dangerous in the use *.

The wood made use of is either alder, willow, or (black) dog-wood; but the distillation in the cylinders making the

* This is clearly seen by the combustion of charcoal, with the bark on, in oxygen gas.

charcoal

charcoal of different woods nearly alike, it is not, I believe, material as to the sorts of wood made use of.

The several ingredients being thus prepared, are ready for manufacturing. They are, 1st, separately ground to a fine powder: 2d, mixed together in the proper proportions: 3d, the composition is then sent to the gunpowder-mill, which consists of two stones vertically placed, and running on a bed-stone. On this bed-stone the composition is spread, and wetted (not with sal-ammoniac, urine, &c. as some authors state, but) with as small a quantity of water as will, together with the revolutions and weight of the runners, bring it into a proper body, but not into a *paste*. After the stone runners have made the proper number of revolutions over it, and it is in a fit state, it is taken off.

A powder-mill is a slight wooden building and boarded roof. Only about 40 or 50lb. of composition is worked here at a time, as an explosion will sometimes happen from the runners and bed-stone coming in contact, and other causes. These mills are either worked by water or by horses.

4th, The composition taken from the mills is sent to the corning-house to be corned or grained. Here it is first passed into a hard and firm body, broken into small lumps, and the powder then grained, by these lumps being put into sieves, in each of which is a flat circular piece of lignum vitæ. The sieves are made of parchment-skins, having round holes punched through them. Several of these sieves are fixed in a frame, which by proper machinery has such a motion given to it, as to make the lignum vitæ runner in each sieve go round with a quick velocity, breaking the lumps of powder, and forcing them through the sieves, forming grains of several sizes. The grains are then separated from the dust by proper sieves and reels.

5th, They are then hardened, and the rougher edges taken off by being run a sufficient length of time in a close reel, having a proper circular velocity given it.

The powder for guns, mortars, and small arms is generally made at one time, and always of the same composition. The difference is only in the size of the grains, which are separated by the sieves of different fineness.

6th,

6th, The gunpowder, thus corned, dusted, and reeled, (which is called glazing, as it puts a small degree of gloss on it,) is sent to the stove and dried; taking care not to raise the heat so as to decompose the sulphur. The heat is regulated by a thermometer placed in the door of the stoves, if dried in a gloom-stove*.

A gunpowder-stove either dries the powder by steam or by the heat from an iron gloom, the powder being spread on cases, placed on proper supports, round the room.

If gunpowder is injured by damp in a small degree, it may be recovered by re-storing it; but if the ingredients are decomposed, the nitre must be extracted and the gunpowder re-manufactured.

There are several methods of proving and trying the goodness and strength of gunpowder. This it is not the object of this paper to describe; but I shall just mention one, by which a good idea may be formed of the purity of the gunpowder, and also some conclusion as to its strength.

Lay two or three small heaps (a dram or two) on separate pieces of clean writing-paper; fire one of them by a red-hot iron wire: if the flame ascends *quickly*, with a good report, leaving the paper free from white specks, and does not burn it into holes; and if sparks fly off, setting fire to the adjoining heaps, the goodness of the ingredients and proper manufacture of the powder may be safely inferred: but if otherwise, it is either badly made or the ingredients impure.

Having thus completed the process of manufacturing, I shall now relate the result of some experiments I have repeatedly made, and which have been made from large quantities in the manufactory.

* This species of stove consists of a large cast-iron vessel projecting into one side of a room, and heated from the outside till it absolutely glows. From the construction it is hardly possible that fire can be thrown from the gloom, as it is called; but stoves heated by steam passing through steam-tight tubes, or otherwise, ought surely to be preferred; for the most cautious man may stumble; and if he have a case of the powder in his hand, some of it may be thrown upon the gloom; and it is surely possible that in this way some of the accidental blowing up of powder-mills may have been occasioned.—Edit.

*Exper.*

*Exper.* 1.—100 parts of composition gain from three to four or five parts in weight, by the water used at the mills.

*Exper.* 2.—This water appears to be totally got rid of by the succeeding processes of manufacturing and stove-drying; and therefore it follows that the only aqueous matter in gunpowder is what may be at first contained in the ingredients.

*Exper.* 3.—The ingredients, only pulverised and mixed, have a very small explosive force.

*Exper.* 4.—Gunpowder granulated after having been but a short time on the mill has only acquired a portion of its strength.

*Exper.* 5.—It is not till it has been the proper time on the mill, and been properly made there, that it has obtained its full powers.

*Exper.* 6.—The strength of gunpowder does not depend on the granulation, the dust of gunpowder after manufacture having nearly the same force as when granulated.

*Exper.* 7.—Powder made in every respect the same, but of two sorts of charcoal, viz. pit and cylinder, is very different in strength—the cylinder charcoal rendering the gunpowder made therewith much superior to that made with pit charcoal.

*Exper.* 8.—Powder undried, in every stage of manufactory, is weaker than when dried.

### *Observation.*

If the composition on a mill explodes by any accidental cause, shortly after it has been put on the stones, it goes off with a very slight explosive force, principally in flame; but if it has been on an hour or two under the runners, and then explodes, it more or less destroys the mill, throwing the boards of the covering and sides to a considerable distance.

I shall here state a circumstance that happened, which, although not immediately connected with the subject, may serve as a strong illustration of one branch of philosophy. On the explosion of the powder in a mill which had been on about two hours, the mill was wholly unroofed and the sides blown out. The doors and windows of the mills on the opposite side of the stream were forced *open outwards,* and the nails, &c. drawn.

In respect to the specific gravity of gunpowder, count Rumford states, that "a cubic foot of water, holding 1000 ounces, will hold 1077 ounces of fine grain powder, well beaten and shaken together; and that the real specific gravity of the solid grains of gunpowder is as 1868 to 1000."

I have, by repeated trials, found that the density of powder varies considerably from various causes in manufacturing, for which reason no exact table of the specific gravity can be given; but I must observe, that the above, as given by count Rumford, is the *greatest* it will ever attain, in my opinion. I have never seen any so much, and I have frequently seen it less than that of water.

In the foregoing account I have confined myself to a simple relation of facts, from a consideration of which the following observations are clearly deduced:

1st, That the explosive force of gunpowder depends very materially on the purity of the carbon employed. (Exper. 7.)

2d, That the mixture *only* of the ingredients does not make that thorough incorporation necessary for the proper combustion and explosive effects of gunpowder. (Exper. 3, 4, 5, 6.)

3d, That the less moisture there is in gunpowder, the stronger is its effect. This is clear, from gunpowder which has attracted any degree of humidity being weaker than when first made.

I shall now beg to submit some ideas that occur to me from a consideration of the whole of the circumstances I have related, and from what may be deduced from an examination of the component parts of gunpowder. It appears to me that no part of the explosive force consists in elastic *vapour*, formed, by the combustion, from water contained in it. So small a portion of water is in the ingredients, and I have observed that not any is gained in the manufacturing, that I cannot conceive any water is carried off undecomposed, but that it is converted into hydrogen and oxygen gases. Mr. Cruickshank observes, "after the explosion of gunpowder over mercury, no water is seen." I am of opinion that the explosive force of gunpowder consists wholly in the several gases formed by the combustion; and that, the quicker it takes fire, the more gas is generated in a given time, and its force consequently

sequently greater. Lavoisier observes, its effect is increased by the quantity of caloric disengaged at the moment of deflagration.

It seems, therefore, that the combustion is carried on by the oxygen supplied from the nitre; that this gas is instantly taken up by the sulphur and carbon; and, converting those substances into carbonic and sulphureous acid gases, azotic gas being at the same time liberated from the nitre, the water which may be in the nitre, and also that which is in the charcoal, is decomposed; and the oxygen taken up by the carbon and sulphur, and the hydrogen set free. The force arising from these gases, with the increased elasticity they receive from the increase of temperature caused by the combustion, is surely sufficient to account for the effects we observe in gunpowder.

It may probably serve to elucidate the subject, if we consider a little minutely what the component parts of gunpowder are from chemical analysis.

*Nitre.* 100 parts of nitre, according to Kirwan, consist of

| | | |
|---|---|---|
| Potash - - | 51·8 | dried in a heat of 70°. |
| Acid - - | 44·0 | |
| Water of composition | 4·2 | |

By several experiments, I have found that nitre which had been dried at 70° loses 3 per cent. in melting.

Lavoisier says, 100 parts nitre consist of

Potash 49, dry acid 51·0; and that this dry acid is,

Oxygen 49·6
Azot 10·4

*Charcoal*, according to Lavoisier, absorbs 2·5714 of oxygen in combustion. From several experiments which I have made, I have reason to conclude, that charcoal, when used, contains about 1-8th part of water, which it has absorbed.

*Sulphur*, according to Berthollet, requires for every 100 parts 36·8 of oxygen to form sulphuric acid; of course, a smaller quantity of oxygen would be necessary for their conversion into sulphureous acid gas: I shall take this at 30 *per cent.*, which is probably not far from the truth, and, at any rate, near enough for our present purpose. No experiment, that I know of, has been made to ascertain this point.

 Admitting

Admitting the foregoing observations to be tolerably correct, the following will turn out to be the quantities of the constituent principles which enter into the composition of gunpowder:

| | | | |
|---|---|---|---|
| 75 parts of nitre, containing | { | Dry nitre | 74·25 |
| | | Water - | 0·75 |
| 15 parts of charcoal - | { | Carbon | 13·13 |
| | | Water | 1·87 |
| 10 parts of sulphur - | | Sulphur | 10·00 |
| 100 | | | 100·00 |

And these again contain, viz.

| Potash. | | Oxygen. | | Azot. | | Hydrogen. | | Carbon. | | |
|---|---|---|---|---|---|---|---|---|---|---|
| 36·75 | + | 30·34 | + | 7·80 | + | 0·11 | | | = Nitre | 75 |
| | | 1·60 | + | | | 0·27 | + | 13·13 | = Charcoal | 15 |
| Sulphur | - | - | - | - | - | - | | - | | 10 |

100 parts of gunpowder, therefore, appear to consist of

| | | |
|---|---|---|
| Potash | - | 36·75 |
| Carbon | - | 13·13 |
| Sulphur | - | 10·00 |
| Oxygen | - | 31·94 |
| Azot | - | 7·8 |
| Hydrogen | - | 0·38 |
| | | 100·00 |

We know that the whole of the charcoal is not consumed in the act of combustion: Mr. Cruickshank says 3 parts remain of 100 parts of gunpowder, therefore only 10·13 parts are destroyed. Now,

| | | |
|---|---|---|
| 10·13 parts of carbon absorb | - | 26·05 of oxygen |
| And 10 parts of sulphur absorb | - | 3·00 of oxygen |
| Oxygen used - - | | 29·05 |
| Quantity of oxygen in ingredients | | 31·95 |
| Surplus of oxygen - | | 2·90 |

It is clear the smallest error in the quantity of charcoal used, will easily account for this difference of oxygen. On the above calculation it seems the quantity of each ingredient is pretty well regulated, and that the gases formed will be expended

expended in producing the effects we observe in the combustion of gunpowder.

The residuum of fired gunpowder Mr. Howard thinks to be an alkaline sulphuret mixed with carbonat and sulphat of potash. But by several trials I have long since made, I am induced to form the same opinion, as to the qualities of this residuum, as Mr. Cruickshank: the quantity I have not had an opportunity of ascertaining. Mr. Cruickshank says: "This residuum is very deliquescent, and when exposed to the air absorbs moisture sufficient to dissolve a part of the alkali; in consequence, the charcoal becomes exposed, and the whole assumes a dark or black colour: that this residuum is potash united with a small quantity of sulphuret of potash and unconsumed charcoal: and that 100 grains of gunpowder yield 53 grains, of which three are charcoal."

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## XLV. *Letter from* M. A. Humboldt *to* C. Delambre, *Member of the French National Institute.*

New Barcelona, Nov. 24, 1800.

DURING my stay in South America I dispatched several letters to you and Lalande. I know you are interested in my fate, and I never let slip an opportunity of writing to you, though I have scarcely any hopes of my letters reaching the place of their destination. I am now on the point of setting out for the Havannah and Mexico, after having performed a tour of thirteen hundred nautical leagues in this part of the New World, situated between Popayan, Quito, and Cayenne. I have slept for three months in the open air, in the woods, surrounded by tigers and hideous serpents, or on plains covered with crocodiles. Bananas, rice, and manioc, have been our sole nourishment; for all provisions soon become putrid in this damp and scorching country.

How grand and majestic is nature among these mountains! From Baraquan and Uruana, which unknown nations have covered with hieroglyphics, as far as the volcano of Duida, at the distance of sixty leagues from the small lake of Dorado, the elevation of which I have found to be 2176 metres, there is only one cordillera of granite, that descends from Quito, and

and proceeds from west to east to join the mountains of the French part of Guyana. What variety among the Indian races! All free, all governing themselves and eating each other, from the Guaicas of Gehetta, a pygmy nation, the largest of whom are about four feet two inches in height, to the white Guajaribos, who have really the whiteness of Europeans; from the Otomacos, who eat a pound and a half of earth per day, to the Marivitanos and the Magueritares, who feed on ants and resin. Having already spoken of all these in a letter*, which I dispatched from the mouths of the Orenoquo to our good friend Pommard, I shall confine myself at present to a few astronomical observations, which, I think, I have made with a considerable degree of care.

My time-keeper, by Berthoud, continues to go with great correctness. I regulate it every four, five, or six days, by corresponding altitudes, taken with my instruments, which do not err a second; viz. sextants by Ramsden and Troughton, a quadrant by Bird, and a horizon by Carroché. You know that I am not very learned in the mathematics, and that astronomy is not the object of my travels; yet with zeal and application, and by daily handling the same instruments, I have been able to do something, and to do it better. As I traversed a country never visited by Europeans till about thirty years ago, in which all the Christian missions do not amount to 1800 souls, and consequently where no one has ever yet been able to make observations, I conceived that I ought not to neglect so favourable an opportunity of enlarging our geographical knowledge. You would have laughed had you seen me amidst the Ydapamianeres Indians in the forest of Casquiara, with my instruments mounted on boxes or trunks, while the shells of tortoises served us as stools. Eight or nine apes, which we carried with us, had a strong desire to handle my hygrometers, barometers, and electrometers also: around all these ten or twelve Indians stretched out in their hammocks, together with fires to secure us from the tigers, which are no less ferocious here than in Africa. The want of nourishment, the mosquitoes, the ants; the chigers, which enter the skin and plough up the flesh; the desire of cooling ourselves in

* This letter, when this was published, had not reached France.

the

the water, and the impossibility of doing it on account of the ferocity of the caymans, the danger of being pricked by the rajas and the teeth of the small carib-fish—youth and a great deal of resignation are required to endure all these. The evil is passed, and I have reaped more than I durst venture to hope.

It is believed (see the map of father Caulin, the best extant, though all the names are wrong,) that the Spanish possessions of Guyana extend to the equator. But I have found, by very good observations of the stars called the Cross and Canopus, which I made among the rocks of Culimacari, that San Carlos del Rio Negro, the most southern establishment, is in 1° 53′ of north latitude; and that the line passes through the government of Great Para, near St. Gabriel-de-las-Cachuellas, where there is a cataract, but not so considerable as the two famous ones of Atures and Maypura.

At Cumana, before the earthquake, which we experienced on the 4th of November 1799, the magnetic inclination, measured with Borda's compass, was found to be 44° 20′ of the new division: after the earthquake it was 43° 35′; the needle made 229 oscillations in the course of ten minutes. Experiments have proved that the magnetic charge has changed in this part of the world, and not in the needle.

At Calabozo, in the centre of Uana, lat. 8° 56′ 56″, long. from Paris 44° 40′ 18″, the inclination was 39° 30′: number of oscillations 222.

At Atures, one of the cataracts of the Orenoquo, in lat. 5° 39′, long. 44° 42′ 19″, the inclination was 32° 85′: number of oscillations 221.

At St. Fernando d'Atabapo, a mission at the mouth of the Guaviara, lat. 4° 9′ 50″, the inclination was 30° 30′: number of oscillations 219.

At St. Carlos de Rio Negro, lat. 1° 53′, the inclination was 23° 20′; number of oscillations 216.

According to the rules given by Messrs. Cavendish and Dalrymple, care was always taken, while observing, to turn the compass to the east and west to find the mean inclinations, and to correct the error which takes place when the axis of the needle does not pass exactly through its two points.

During

During this journey, which lasted a year, I determined 51 points of South America, in which I observed the latitudes and longitudes: the former deduced, for the most part, from the meridian altitude of two stars at least; and the latter, either from the distances of the moon from the sun and stars, or from the time-keeper and horary angles. I am now employed in constructing a map of the country through which I have travelled; and as my observations fill up the vacuum found in the maps between Quito and Cayenne, to the north of the river of the Amazons, I flatter myself that they will be interesting to geographers.

My time-keepers have not given me with exactness, but the differences of meridian between the places of my departure and the Caraccas, Cumana, and St. Thomas de Nueva-Guayanna, lat. 8° 8′ 24″, long. 21 of time, east from Cumana. I am very anxious, therefore, on account of my map, to fix the position of these three places in regard to Paris, and by observations purely astronomical. Besides, it is very necessary that navigators should be able, at the time of their arrival on this coast, to find the longitude of the ports well determined, that they may know the state of their chronometers; for, except Martinico, Guadaloupe, Portorico, where M. De Churucca observed; Cayenne, and Quito, there are very few places the longitude of which can be depended on; especially in Spanish America. Carthagena, according to the *Connoissance des Temps*, is at 5h. 12′ 12″. But the three emersions of the satellites, observed by Herrera, all give 69° 24′ 10″ west of Cadiz, or 5h. 13′ 11″ to the west of Paris.

I observed, with a telescope of Dollond, which magnifies 95 times, at Cumana, in lat. 10° 27′ 37 :

The immersion of the second satellite Nov. 7, 1799, at 11h. 41′ 18″ true time.

Of the second satellite, Sept. 11, at 16 h. 31′ 0″ true time.

Of the first satellite, Sept. 25, 1800, at 17 h. 10′ 21″ mean time.

The *emersion* of the 4th satellite, Sept. 26, at 17 h. 28′ 0″ mean time.

Of the third satellite, Sept. 27, at 16 h. 25′ 55″ mean time.

Of the fourth satellite, Sept. 26, at 17 h. 28′ 0″ mean time.

I am

I am therefore mistrustful of the longitude of Cumana, as given me by my time-keeper. When I arrived from the Canaries at the Continent, I found the longitude to be 4 h. 26′ 4″; and the observations of M. Fidalgo, who observed emersions at Trinidad, but not at Cumana, give still more; viz. 4 h. 26′ 16″. Fidalgo found Trinidad 55° 16′ 32″ to the west of Cadiz, and Cumana 2° 41′ 25″ to the west of Puerta España. But the map of Trinidad, published at London, from the excellent observations of M. De Charucca, makes Puerta España 61° 22′ west from London. I am of opinion, therefore, that, in constructing the map, the authors had before them the calculations by Lalande of the occultation of Aldebaran, observed at Porto Rico on the 21st of October 1793; for the capital of Porto Rico is by the time-keepers 4° 34′ to the west of Puerta España, calculating the longitude by that of Porto Rico 63° 48′ 15″; and for Cumana 66° 29′ 40″ to the west of Paris. The five eclipses of the satellites which I send you must throw light on this subject; and in my opinion the longitude of Cumana will not be much beyond 4 h. 25′ 20″. Unfortunately, the eclipse of the sun, which I completely observed on the 28th of September at Cumana, making the horns pass along the horizontal and vertical wires, was not visible in Europe. I observed the end at 8 h. 14′ 22″ mean time; the time certain to 1″ nearly, having taken corresponding heights the same day.

At Carras (Plaza della S. Trinidad) lat. 10° 31′ 4″, I observed:

The *immersion* of the first satellite, Dec. 7, 1799, at 16 h. 11′ 57″ true time.

Of the third satellite, Dec. 7, at 17 h. 11′ 36″ true time.

The *emersion* of the first satellite, Jan 17, 1800, at 11 h. 14′ 8″ mean time.

Of the second satellite, Jan. 28, at 7 h. 58′ 8″ mean time.

Of the fourth satellite, Jan. 18, at 8 h. 13′ 3″ mean time.

At the Valle del Tuy al Pic della Cocuiza, lat. 10° 17′ 23″.

The *emersion* of the first satellite, Feb. 9, 1800, at 11 h. 26′ 57″ mean time.

Of the third satellite on the 10th of February, at 7 h. 58 50 mean time.

But these last eclipses were observed with a telescope of Caroché, which, though a very good one, magnifies only 58 times, not being able to carry along with me, to Rio-Negro, the large telescope by Dollond.

Declination of the magnetic needle at Cumana on the 27th of October 4° 13′ 45″; at Caraccas, 4° 38′ 45″; at Calabozo, 4° 54′ of the old division.

The port of La Guayra is exactly 29″ in time west from Caraccas; and I hope that, by giving immersions and emersions, the meridian of Caraccas will be properly fixed.

I have described, with Bonpland, more than 1200 plants*.

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## XLVI. *Proceedings of Learned Societies.*

### ROYAL SOCIETY OF LONDON.

APRIL 30. The reading of Dr. Herschel's observations on the nature of the sun was concluded. The doctor remarks that, if the luminous matter of the sun was a fluid, or even of a nature similar to an atmosphere, every opening must, by the laws of hydrostatics, be instantly filled up. His supposition is, that the sun is surrounded by an atmosphere of considerable density on which the luminous matter floats, and which he conjectures to be of similar nature to our clouds. Having consulted all the astronomical acounts of observations on the telescopic appearance of the sun, and compared them with the registers of the price of corn for those years in which they were made; he infers, from a careful examination of the whole, that in those years in which few openings were seen, there has been a rise in the price of wheat in consequence of a scarcity, arising from a smaller emission of the matter of heat.

* A Letter from Haspel-la-Chenaye, chemist at Guadaloupe, dated Jan. 5, states, that M. Humboldt had set out for the Havannah, after having left with the agent of the government at Guadaloupe a box for the Institute and two packets, one for Fourcroy and the other for Delambre. As the box has not yet arrived, nor the packets addressed to Fourcroy, it is to be presumed that the above letter is not that mentioned by Haspel-la-Chenaye.

On

On May 7th was read a paper by Everard Home, Esq. on the grinding teeth of the wild boar.

On the 14th, additional observations on the emission of light and heat from the sun; being a continuation of the observations on the nature of the sun; read April 16, 23, and 30: by Dr. Herschel. These additional remarks are the result of observations made from the 2d of March to the 3d of May, and during the late mild weather; and tend to confirm the Doctor's former conjecture, as on some of the days there were no less than sixty openings. The Doctor supposes that one side of the sun has the power of sending forth more heat than the other. As great inconvenience resulted from the heat transmitted through coloured glasses, he viewed the sun through fluids. Alcohol, Port wine, ink diluted with water, which gave an image of the sun as white as snow; and even common water, answered the purpose of stopping the heat remarkably well.

A paper by Thomas Andrew Knight, Esq. on the ascent of sap in vegetables, was partly read the same evening, and was concluded at the following meeting. It contains a vast assemblage of curious facts, observations, and experiments, on the physiology of vegetables.

## FRENCH NATIONAL INSTITUTE.

The following is an account of the labours of the Class of the Mathematical and Physical Sciences during the second quarter of the year 9:

### *Mathematical Part read by* Lalande.

Lalande read a memoir on the longitude of Alexandria in Egypt, which he determined by an emersion of the star Antares, compared with a complete observation of the same eclipse made at Marseilles by Thulis, associate of the Institute. It results from this calculation that the difference of the meridians is 1° 50′ 26″, which varies a little from that established by Nouet and Quenot. The position, therefore, of this point seems now to be well known.

Prony read a notice on the grand decimal trigonometrica tables, calculated under the direction of Lalande, by a method entirely new, and which is attended with this advantage, that

that an indefinite number of calculators might be employed at the same time, the greater part of whom would have occasion for no other knowledge than that of addition and subtraction.

*Galvanic Experiments.*—C. Cuvier stated the different opinions that have been advanced respecting the galvanic fluid, and how far its effects were supposed to affect the received doctrines respecting the composition of water; but from the length of his notice on this head, and the period at which it came to hand, we are obliged to defer it till next month.

The other notices read by Cuvier were the following:

*Discussions on the Composition of Water.*—While Fourcroy and Vauquelin were defending the French chemistry against the objections which galvanism gave rise to, C. Van Mons, associate resident at Brussels, was combating an adversary who employed arms of another kind.

M. Wiegleb, a German chemist, having made water in a state of vapour to pass through different kinds of tubes containing different matters, obtained gases different from those which compose that liquid, according to the pneumatic theory. He thence concluded that water can be changed according to circumstances into various kinds of gases. Some of the Dutch chemists, having repeated and varied these experiments, found that the gases obtained had penetrated through the pores of the tubes, the matter of which was not sufficiently compact; that they were always produced by the substances with which these tubes were surrounded, and that by employing impermeable tubes nothing of the like kind was manifested. M. Wiegleb wrote a reply to the Dutch chemists, and Van Mons has now refuted his answer in a Latin memoir. As we cannot here enter into a minute discussion of this subject, it will be sufficient to observe that the result of Van Mons is entirely favourable to the French theory.

*Means of purifying the Air.*—Three months ago I gave an account of Guyton's labour on the means of purifying the air, preventing contagion, and checking its progress. He continued the reading of his paper at some sittings of this quarter,

quarter, and it will soon be submitted to the public. Guyton has obtained the most gratifying reward that a philosopher can expect for his researches: it was in a great measure by the processes he has pointed out, viz. fumigations with the muriatic acid, that the epidemical disease which ravaged Andalusia was destroyed. This fact appears from the report made to the Spanish government by Dr. Queralto, sent from Seville for that purpose, and the report communicated to Guyton by M. Gimbernat, one of the pensioned travellers of the king of Spain.

*Extraction of Soda from Marine Salt.*—Berthollet has been employed on a subject of great importance to the arts, the decomposition of marine salt. Leblanc having published a process for extracting the soda, Berthollet has made some changes in it which render it more advantageous, easier, and applicable with more œconomy to the different arts in which the oxygenated muriatic acid is used.

*On the supposed Returns of the principal Variations of the Atmosphere.*—To be able to foretel the variations of the atmosphere would be a thing of so much general utility, that it needs excite little astonishment that it should, at all times, have been an object of research to philosophers; and it ought to excite less, that the obscurity in which this as well as every other part of futurity is involved, has made those who pretend to foresee the variations of the air to be ranked in the same class as those who pretend to foretel moral and political changes. It may, however, be easily seen that these events are not of the same order; that the causes of the former are much less varied, and consequently are susceptible of combinations less numerous; that these causes have not the mobility of the affections of the mind; and that, if some of them still escape us, it is not necessary they should do so always.

These reflections induced Lamarck to examine the following question:—"Among the different variations of the state of the atmosphere, and especially those observed in our latitudes from 40 degrees to the poles, are there any the periodical return of which can be determined?" Lamarck has been able to convince himself that the solutionof this question cannot

not be obtained unless three means, which he points out, are employed in conjunction: of these means we shall mention that only which consists in the establishment of a regular correspondence of observations made every day in different parts of an extensive country, in order to ascertain whether the great atmospheric variations observed in any one place are really the result of any cause which has a determinable periodical return. This means, says Lamarck, is so essential that it is astonishing it should have been hitherto neglected.

After laying down these bases, Lamarck gives an account of the results he has been able to obtain: he distinguishes them into the knowledge of facts which cannot be doubted, and simple observations. The alternate elevation or depression of the moon, above or below the equator, in the course of each lunar month, produces in the atmosphere, according to this author, very apparent effects. During the austral declination of the moon, and particularly on the approach of the austral lunistice, the winds which then prevail blow from the regions of the north, north-west, or north-east, or east, or from some of the points comprehended between these points. The constitution of the atmosphere thence resulting tends to give dry or cold weather, according to the season, and to restore a bright atmosphere and fine weather. During the boreal declination of the moon, and particularly the approach of the boreal lunistice, the prevailing winds blow from some of the points opposite to those mentioned above as predominant during the austral declination. The atmospheric constitution thence resulting tends to give cloudy weather, more or less damp and rainy. It is favourable to the formation of storms, which never take place but during this declination of the moon.

Among the signs which Lamarck considers as simple observations I shall mention only the following, and shall employ the same expressions as the author.

"As the position of the lunar points changes very slowly, which makes them fall for several months successively, sometimes on the lunisticial days and sometimes on the mean days, this position gives rise to that stationary state of the atmosphere which

which is observed in such or such season of certain years, which renders these seasons and these years singularly remarkable."

## XLVII. *Miscellaneous Articles.*

### ELECTRICITY.

A Correspondent, Mr. Richard Hunt, of Howden, observes that it is commonly held "that for the purpose of exciting electricity by a machine, communication with the earth is necessary, either from the cushion or the conductor; and, above all, that in charging jars the jar must communicate with the earth; but that this is not quite correct, all that is gained by such a communication being neither more nor less than an indirect connexion being established between the cushion and the outside of the jar. Accordingly he finds that if the machine, the jar, and the operator be all insulated, still the jar may be charged *if a communication has been established between the outer coating and the cushion* by means of a wire or any conducting body interposed between them."

Our correspondent probably knows that by means of Mr. Nairn's electrical machine two jars are charged without having any connexion with the ground, and that in this case, as well as the one he has stated, the effect may be satisfactorily explained by the present or by the Franklinian theory.

### ANTIQUITIES.

The East India Company has received from its agent at Bagdad twelve bricks of those which are still remaining near *Hilla*, on the Euphrates, on the spot where the antient Babylon, according to Major Rennel and other geographers, is supposed to have stood. On these bricks characters are engraved perfectly similar to those which are found in Persia on the ruins of *Chehilminar*, about a day's journey from *Shiraz*, and commonly called *Persepolitan*. These characters, which have already been noticed by *Le Bruyn*, *Kämpfer*, *Niebuhr*, and others, have hitherto been reckoned peculiar

to

to these ruins, being only found on blocks of marble or on gems dug up there. By the discovery, however, of the present bricks it has been proved that they were used also in other parts, having been found amongst the ruins of the antient capital of Chaldæa. Besides, having received by this means more copious specimens of that species of writing, it will become easier to decide whether these characters are of the alphabetic, or syllabic, or hieroglyphic kind, whether they ought to be read from the right or from the left, horizontally or perpendicularly, from the top or from the bottom. Perhaps each word may be expressed by a particular group, like those antient characters of the Chinese published lately in London by the learned Dr. Hagar, where, instead of *nails*, like those now made use of, leaves, flowers, bracelets, snakes, and other representations, are employed, arranged in different positions to express different words.

## NATURAL HISTORY.

A correspondent sends us the following curious notice:— "In the year 1794, a hen belonging to Captain Nicholson, Duke-street, Whitehaven, swelled to an enormous size, which continued near five weeks, when she died. One of his sons cut her open for a favourite dog, when he discovered an egg of a prodigious bulk, which was found to contain two chickens. These chickens were carried to Dr. Wylie of the same place, where the egg and its contents may be seen. The flesh of the hen was turned entirely black."

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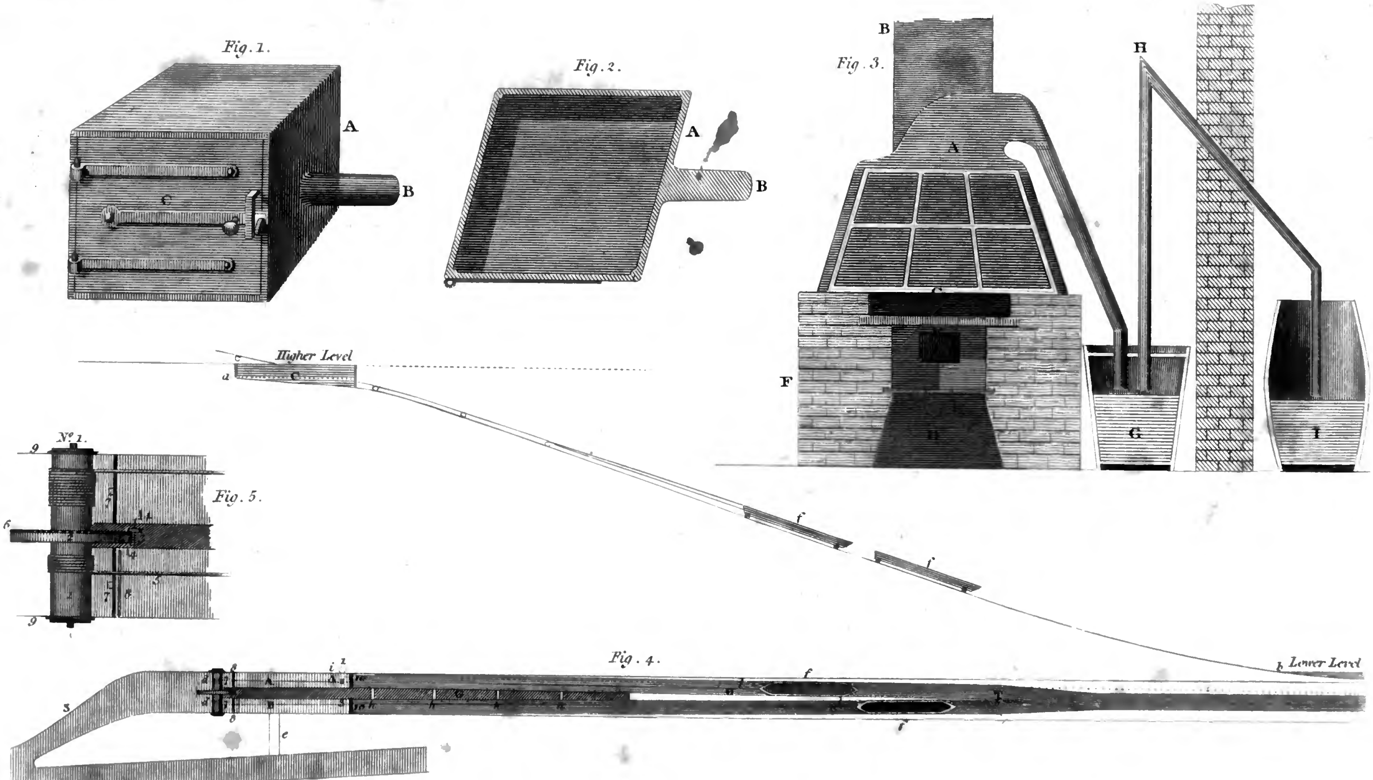
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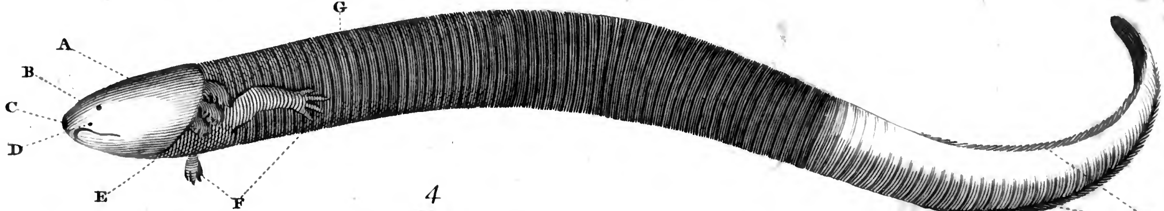


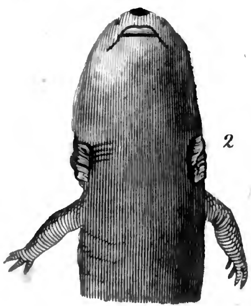

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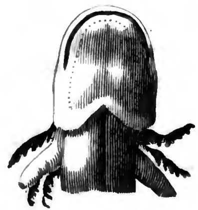

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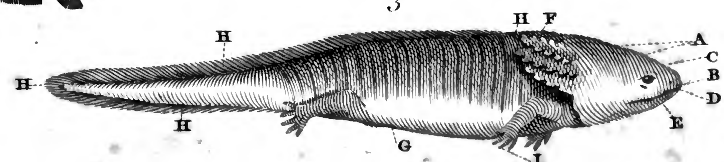

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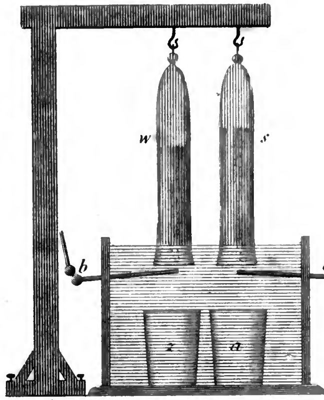



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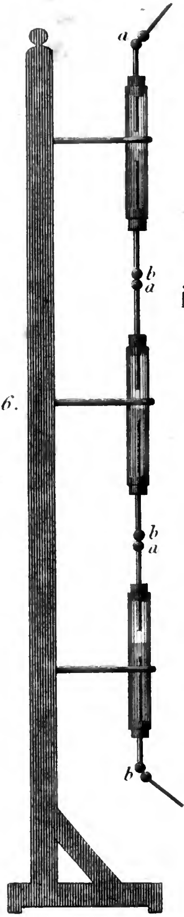


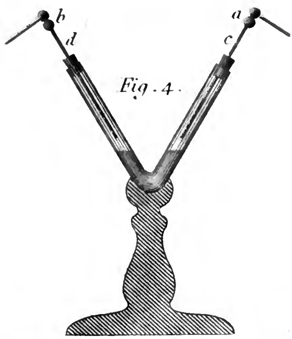


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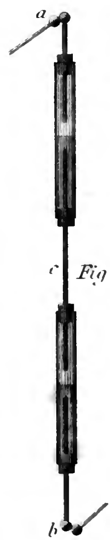


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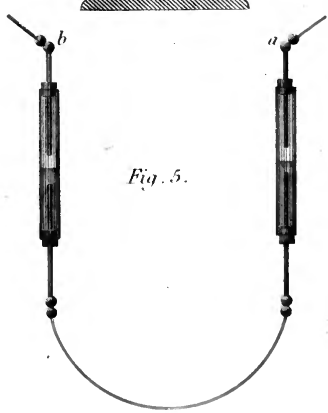


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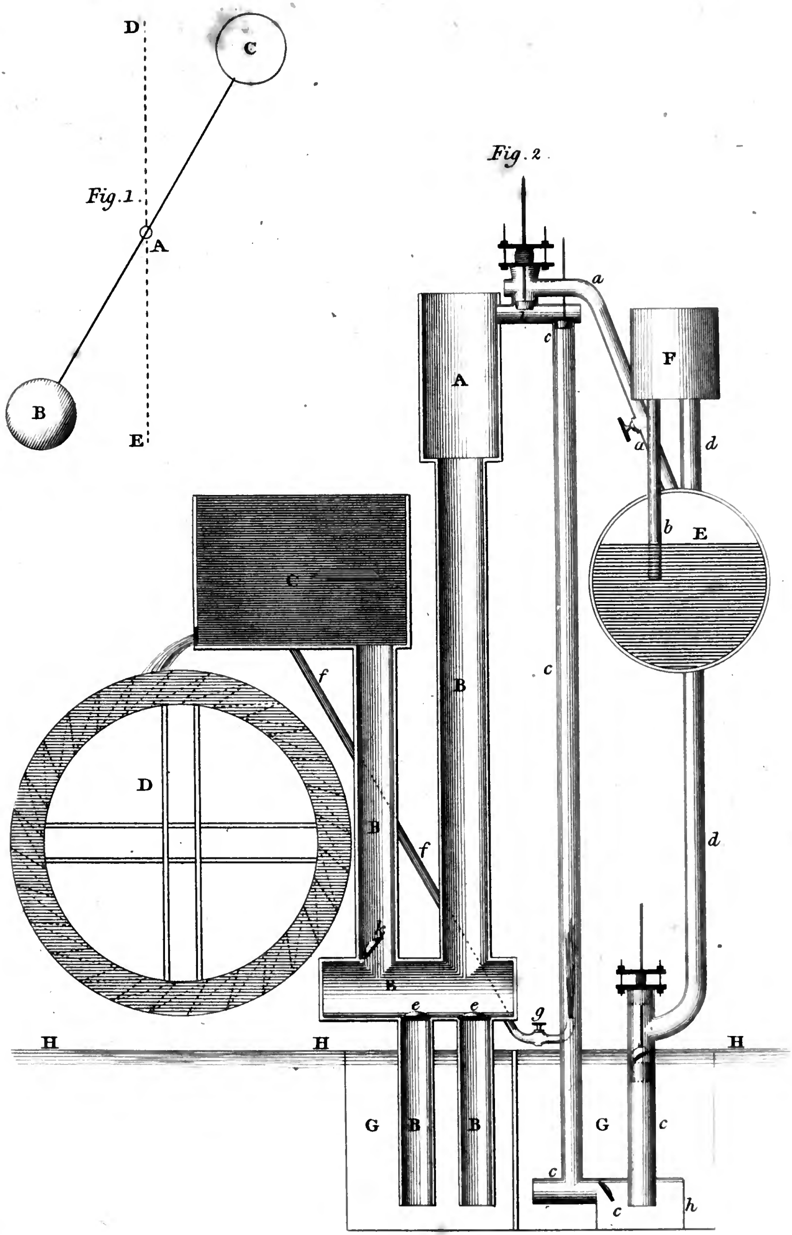




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